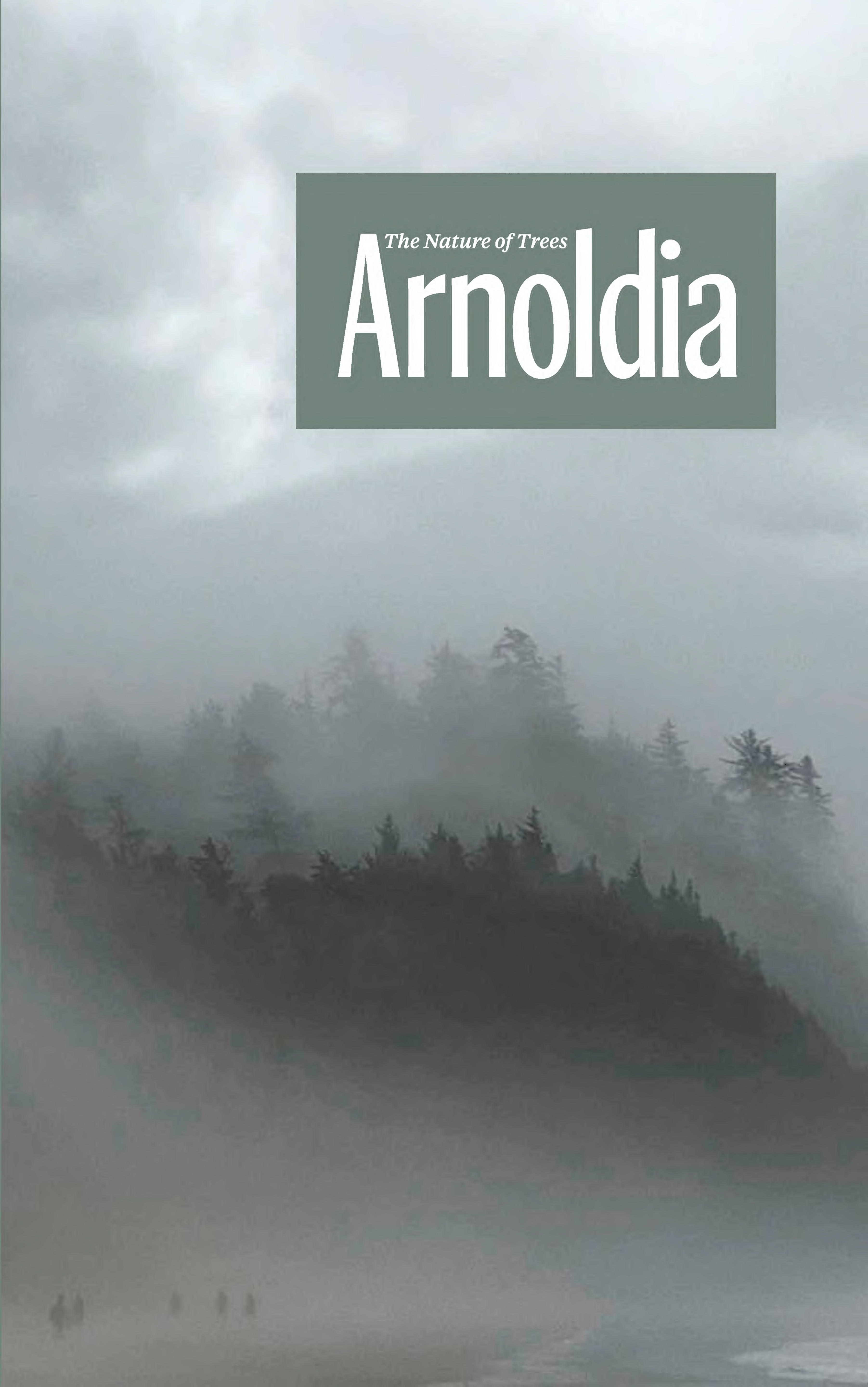
Buds in Winter   *Oak and Pine in Life and Death*   *Roots of Rejuvenation*   *Olmsted Trees*

WINTER 2022

The Nature of Trees

Arnoldia



Converging Paths

By Matthew Battles

Two roads diverged in a yellow wood: Frost's words come to mind unbidden as I walk through the Arnold amid November's yellowing days, following forking paths that might take me to the Hunnewell Building and the workday, to Weld Hill for a lecture, or into the conifers for a quiet afternoon copyediting in the company of wild turkeys. It's worth remembering that intersections are also *con*vergences, comings-together for travelers from different points of origin. The arboretum itself is such an intersection, where two grand ways of working with plants, the scientific and the horticultural, converge. How many other ways of knowing, feeling, and storying trees also meet at this crossroads?

Some convergences come after long travel. Turning off Meadow Road, I approach the golden glow of the katsuras—though even before I arrive, they've already announced themselves by their characteristic caramel fragrance. One of these specimens of *Cercidiphyllum japonicum,* 882*A, is among the oldest trees in the arboretum, accessioned in 1878. But katsura's path is far older: fossil evidence shows them thriving in forests of the northern hemisphere by the end of the Cretaceous, some seventy million years ago. We say that katsura smells like cotton candy—the German name for the tree is *Kuchenbaum,* or "cake tree"—but isn't it properly the other way round? Cakes and cotton candy, those latecomers, smell like katsura, whose fragrance of toasted sugar, tens of millions of years in the making, likely wafted long before there were noses attached to humans with a propensity for naming, propagating, and choosing tree-convergent ways.

So these converging paths through trees are generous, gregarious, inspiring. Richard Powers begins his 2018 novel *The Overstory* with a powerful invocation of trees as generous storytellers:

> *A woman sits on the ground, leaning against a pine. Its bark presses hard against her back, as hard as life. Its needles scent the air and a force hums in the heart of the wood. Her ears tune down to the lowest frequencies. The tree is saying things, in words before words.*

It says: Sun and water are questions endlessly worth answering.

It says: A good answer must be reinvented many times, from scratch.

It says: Every piece of earth needs a new way to grip it. There are more ways to branch than any cedar pencil will ever find. A thing can travel everywhere, just by holding still.

The woman does exactly that. Signals rain down around her like seeds.

These converging paths through trees are generous, gregarious, inspiring.

With this year's Spring issue, *Arnoldia* debuted a new design and editorial format; in the very same moment, I joined as editor. I can take no credit for this new vision for the magazine, which was brought forward by Michael Dosmann, and my predecessor, Jonathan Damery, in collaboration with members of *Arnoldia's* editorial committee and our consulting design studio, Point Five. I've been thrilled by all the new ways they have furnished me to know, story, and connect with trees—not only through a profusion of new literary forms, including poetry and creative nonfiction, but drawing from the visual arts as well. We've welcomed verse from emerging and prizewinning poets, and book excerpts from provocative scholarly works like Rosetta Elkin's *Plant Life* (Fall), to *Cold Canyon Fire Journals* by Robin Lee Carlson, whose distinctive, lyrical art and storytelling about wildfire and place in California enriches this issue (page 16). Our editorial artist, Matt Huynh, provides each issue's Notes from the Field section with a fresh set of expressive illustrations, while our endpapers by Shyama Golden frame the magazine with sumptuous assemblages drawn from the shifting seasons. At the same time, this renewed *Arnoldia* also brings forth the scholarly and scientific research that have long been the magazine's mainstay, such as Peter Del Tredici's article in this issue on the fascinating phenomenon of endocormic roots (page 30). And most crucially, we're making space for authors whose voices historically have not been heard along the paths of science and the garden. Native voices, the voices of folks of color, the unhoused—*Arnoldia* seeks to come into restorative relation with such authors, and to bring the knowledge they carry to our readers.

Arnoldia's rebirth comes at a time of both richness and urgency, with an efflorescence of innovative writing about the natural world arriving from new directions, prompted by climate change, calls for environmental justice, and the enormity of the biodiversity crisis. And so now is a crucial time to bring forth this expanded editorial mission and toolkit for telling tree-entangled stories.

Meanwhile, the Arnold's paths proliferate. The horticulture team has been laying new trails throughout the landscape, giving visitors more immediate access to our collections. And in the years to come, the Roslindale Gateway Path Project will connect Forest Hills to Roslindale Center, making even more of this living landscape into an equitable contact zone. As these paths intersect, new stories surely will emerge.

Our former tagline was *The Magazine of the Arnold Arboretum;* now, it's *The Nature of Trees*. An intersection for more than science and horticulture, this nature is a gregarious convergence of lyric, memoir, storytelling, and scholarship. Who speaks to the nature of trees? Everyone. May *Arnoldia* continue to be as generous as the katsura, as message-bringing as Powers' fragrant pine. May it be a crossroads, a meeting place. And may it always be thronged with trees.

MATTHEW BATTLES *is the editor of* Arnoldia.

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When fire comes to the chapparal, gray pines mostly die, returning to the landscape as new sprouts. *Illustration by Robin Lee Carlson*

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Arnoldia
The Nature of Trees

Volume 79 | Number 4 | 2022

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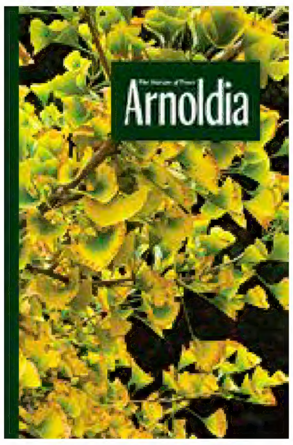
LETTERS



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Welcome Gates and Paths

I'm writing in response to the Arboretum's web page describing the Roslindale Gateway Path Project. This is the coolest thing ever! I've always wanted the wooded area along the railway to be accessible. As it is now, the railway is an obstacle that you have to go a long way around to get through. This project cleans it up, and makes it a welcoming portal to a green area that can become a real treasure for this neighborhood. A green walkway from Forest Hills to Roslindale Square, with access points along the way, is a wonderful improvement.

The website itself is very fun to interact with, too. Have fun exploring!

I want to add that when I worked at the Arboretum from 1979 to 1982, it was very isolated from the neighborhood. The staff was a wonderful group of people who were fascinated by plants and enjoyed taking care of them. But most of us lived somewhere else, and the place felt like a world unto itself, separate from the people who lived nearby. I have been delighted over the years to see it become more and more welcoming, both through programming and physical accessibility. It is now a well-loved treasure, which motivates more people to want to take care of it, and more people to care about the natural world.

Laura Derr
(Boston resident and former
curatorial and propagation assistant
for the Arnold Arboretum.)

A Green City Takes a Village

Thank you to Matthew Stephens, whose op-ed on the importance of advocacy for trees in cities ("Of Trees and the City," Summer 2022) struck a chord with me and with many others.

As stated in the article, "(b)eyond their value as carbon store, trees provide real and tangible benefits in the form of cleaner air, shade for buildings, or stormwater capture among many, many others." Mr. Stephens made a strong case for trees to be funded as critical urban infrastructure, "key to the safety and well-being of residents."

The story of urban trees in Boston is one of good news and bad. On the bright side, Boston recently completed an Urban Forest Master Plan and hopes are high for its implementation. There are many local individuals and organizations, large and small, who recognize the significant benefits that urban trees provide. They are dedicated to a range of education, stewardship, and advocacy for urban trees and their planting, preservation, and restoration. The list is too long to include in a letter (brainstorming quickly yielded 39).

On the less bright side, the challenges are daunting: Trees continue to be lost in every neighborhood—to development, storm damage, pests, natural aging, and even sometimes to make space for solar panels. A tree protection ordinance was proposed at the Boston City Council in 2021, but it has not moved forward

Closing quotes from Mr. Stephens:

> *Urban forestry managers must scratch and claw for every dollar they get. And trees get pennies on the dollar compared to other urban infrastructure.... The time for policy change is now. We need those who will speak for the trees, knowing they are a critical part of the urban infrastructure.*

Thank you again to all who are already engaged on behalf of urban trees. To everyone else: please join us!

Sarah Freeman
(Organizer working with many public-space advocacy organizations in Boston, including Trees as a Public Good.)

The story of urban trees in Boston is one of good news and bad.

Of Plants and Presence

In the fall issue, Michael Dosmann put into words what I see in each plant out back: "a richly authentic connection to a human." I don't mean me—though I have become part of their stories, too—but the person who sold or gave it to me. Their presence is felt. Even for those of us lacking proper accession records like the Arnold's, such informal provenance is part of the joy, forming our bond with every plant.

The first thing I planted in my garden decades ago was a Japanese umbrella pine (*Sciadopitys verticillata*), dug up from brief earlier garden experiments and moved farther north to the Hudson Valley.

The nursery I bought it from is long gone. But in my brain stuffed with too much miscellany for its own good, I think I remember their source: the former Baier Lustgarten Farms in Long Island, known for excellence in conifers and other woodies.

I know where every plant here on 2.3 acres came from—or I should say *who,* to Dr. Dosmann's point. Like the tiny 'Lustgarten Weeping' kousa dogwood Dan Hinkley sent me from near Seattle decades ago, its roots in a mere sandwich bag of soil tied with a rubber band, now all grown up right near the *Sciadopitys.* I like to think these two plants share some Lustgarten history, despite the different routes they took since, thanks to the passion of human facilitators.

Across the garden, a collection of herbaceous peonies gifted to me over the years by their breeder, Roy Klehm, had become too shaded for their own good. The other day, a neighbor and I dug them up, and divided each clump so that she, too, could live with some of Roy's genius. The tradition continues.

Margaret Roach
(Author of the "In the Garden" column for the New York Times *and creator of the website, book, and podcast,* A Way to Garden.*)*

Notes from the Field

Bud Morphology

Morgan Moeglein investigates the big bets trees make at the scale of the buds where leaves form for the season to come.

Morgan Moeglein is an assistant professor in biology at Norwich University, and was a Putnam Postdoctoral Fellow at the Arnold Arboretum in 2021–22.

Every fall across the temperate latitudes, the leaves of woody plants complete development, reach their final form, and begin to senesce. Leaf senescence marks the end of a growth cycle that may seem to begin at bud break in the spring, but for many leaves actually began much earlier, during the previous growing season, hidden from view within a resting bud. Leaves that initiate and mature within a single growing season are known as *neoformed* leaves. *Preformed* leaves, by contrast, initiate during one summer, undergo one or more periods of winter dormancy, and complete their life cycle in the following summer. Botanists have long noted the presence of incipient leaves within dormant resting buds. Many unanswered questions about leaf preformation remain, however. When we look at a tree at the end of the summer, how many of those leaves were preformed? Do different species employ different strategies when they invest in preformed leaves for future seasons?

I have spent the last year trying to characterize how plants invest resources in their overwintering buds and the leaves within. This work led me to the Arnold Arboretum, where I set out to investigate how preformation contributes to leaf development across woody taxa. The first step in this work was to look very closely at dormant buds in the field.

Surveying buds across species in the depths of winter, without the obstruction of leaves, is the best time to appreciate how much bud morphology varies. Some overwintering buds are obvious, such as the long, shiny beech buds or the furry, gray magnolias. Then there are the minuscule

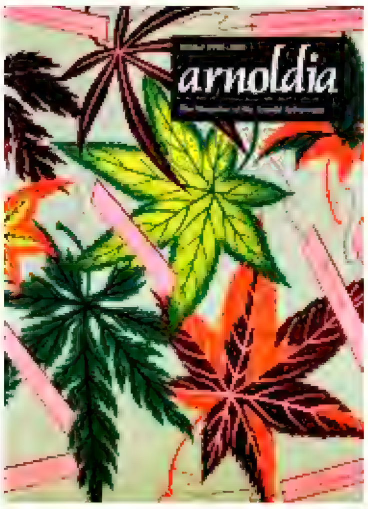
Illustrations by Matt Huynh

and hard to find: the buttonbush bud barely raised from the surface of the twig, or the winterberry with its few, tiny, camouflaged bud scales. Walking through the collections sampling dormant buds for future microscopy, I easily snapped the bigger buds from their branches with my fingers, while smaller specimens had to be shaved from twigs with a razor blade back in the lab.

Even more remarkable than the external bud morphology observed in the collections is what you find inside after dissections under the microscope: the large, showy buds usually contain mature-looking leaves in miniature. The morphological intricacies of an oak or sweetgum leaf are already apparent, intact in these preformed leaves, months before they expand to their mature size. Even in the smallest buds, many leaves are already initiated, their shape recognizable in its relation to the mature form. A tiny, flattened catalpa bud may contain ten leaf primordia, similar to the number of mature leaves that will be present at the end of the growing season. It's astonishing to realize, while looking at buds in the field, that the form and number of mature leaves could be determined so far ahead of time, within the tiny space of the smallest buds.

Large, showy buds usually contain mature-looking leaves in miniature.

By comparing preformed leaves dissected from within buds to mature, fully expanded leaves, I hope to deduce how much of the multi-seasonal cycle of leaf development occurs within buds relative to the end-of-season total. Looking at preformed leaf and bud measurements relative to mature leaf measurements allows us to measure relative investment in different leaf components, and begins to reveal patterns in preformed investment. These strategies can tell us something about how plants prepare for the future. Some species may preform more leaf tissue that is more fully developed in preparation for expected circumstances in the coming growing season, while others may wait and neoform the leaves they need in real time as a response to present growth conditions. There are also different ways to invest. One species might invest in many small leaves, while another might invest in fewer leaves that are larger and more completely developed. With so many different ways to invest in preformation, the range between preformation and neoformation begins to seem more like a spectrum than a dichotomy. Based on observations so far, I suspect the species surveyed will vary widely in the timing and



Arnoldia 54(4), 1994–5. Under Karen Madsen's editorship, the magazine often featured bold, memorable covers.

IN MEMORIAM

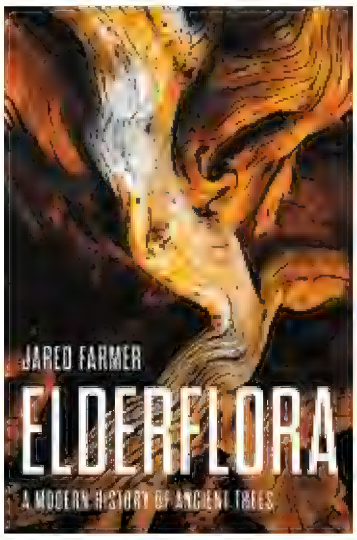
Karen Madsen 1942–2022

Karen Madsen edited Arnoldia *from 1993 to 2007, leading the magazine through dramatic changes in publishing and printing. Perhaps no one at the Arnold worked with Karen more closely than Peter Del Tredici, who offers the following remembrance:*

I first met Karen in 1988 when she was a student in the Radcliffe Seminars program, working on her thesis on Woodlands, the famous garden of William Hamilton, who introduced the Ginkgo tree into North America in 1784. When I was appointed editor of *Arnoldia* in 1989, I asked Karen to contribute a short version of her thesis. We got along well during the editing process, which is not always a given, and I hired her part time to help me with copyediting. After I became Director of Living Collections in 1992, Karen was appointed to replace me as editor. Not only was Karen a good friend, a great writer, and a skilled editor, but she helped make landscape design history one of *Arnoldia's* specialty topics.

extent of their investment in future leaves.

Surveying the contents of overwintering buds can help us learn how plants invest in leaves from season to season—but it may also better our understanding of the evolution of leaf form more broadly. Leaf shape varies massively across plants, but the variation within species or within individuals can be just as impressive. Leaf shape along a single growing tip can vary over the course of a season and this variation may correspond to preformed and neoformed trajectories arising from different developmental programs. Leaf-shape plasticity could provide standing variation for evolution to act upon, or it might open up different photosynthetic options as the season progresses. If the shape of preformed leaves is largely predetermined within the dormant bud, and if this shape is different from the shape of neoformed leaves later in the season, the confined nature of development within a bud may have some influence on leaf shape. The same may be true when comparing across species with different preformation strategies; a species that preforms more may be more likely to have certain leaf shapes than a species that produces more leaves through neoformation. There are many possibilities, but looking within dormant buds at the earliest stages of leaf development across species and environments may illuminate our understanding of the variation we see across mature leaves.



ELDERFLORA:
A Modern History of
Ancient Trees
By Jared Farmer
Published by Basic Books
Hardcover | 448 pages

BOOK BRIEF

Older Than the World

"Trees," writes historian Jared Farmer, "are plants that people call trees—a term of dignity, not botany." And it is the largest and, especially, the eldest that have commanded the greatest dignity, from the the Buddha's Bodhi Tree to Methusaleh, the bristlecone pine in California's Inyo National Forest thought to be the oldest non-clonal tree in existence. Believers held that the Oak of Mamre in Jerusalem had been growing since the dawn of creation—a tree older than the world itself. By the time this tree finally fell in the yard of a West Bank monastery, far older trees had been identified by scientific means. And yet fascination for trees like the giant sequoia accompanied a rush to cut them, nearly leading to their disappearance. Farmer's book explores the mythmaking, veneration, and exploitation to which the oldest and largest trees have been subjected through time, and poses an urgent question: in the wake of the industrial era, under the cloud of climate change pushing them to the brink, do these elder flora have a future? We need them to survive, Farmer argues, if we are to make sense of changes we have set in motion in deep time.

Illustration by Matt Huynh

The Hidden Ice of Plants

In the wilds of the laboratory, **Camilo Villouta** captures the fleeting effects of freezing water where flowers form.

Camilo Villouta is a Putnam Postdoctoral Fellow at the Arnold Arboretum.

When studying how plants in winter deal with freezing temperatures, the observation of ice formation in their tissues is especially elusive. I addressed this topic in my dissertation, which challenged me to find new methods to answer them. At the time, I was a PhD student at the fruit crops lab at the University of Wisconsin-Madison, under the guidance of Dr. Amaya Atucha. Our goal was to understand the development of cold hardiness in the terminal buds of cranberry (*Vaccinium macrocarpon*). Most importantly, we wanted to know what strategy they used to withstand and survive ice formation.

In woody perennial flowering species, buds are known to survive exposure to freezing temperatures by either of two freezing survival strategies. Both follow a similar principle: avoid the formation of ice crystals with their potential of causing lethal damage in the flower primordia, tissues that are the precursor of the mature flower. These strategies have extravagant names, which nonetheless describe their main characteristics very well. On one hand, we have “deep supercooling,” where buds avoid the propagation of ice into the flower primordia, keeping them ice-free even when they are at subfreezing temperatures. The other strategy is named “extraorgan freezing,” where the flower primordia dehydrate, pushing water away from themselves towards the ice-tolerant bud scales. In the case of cranberry terminal buds, we needed to determine which strategy was at work, both to interpret damage patterns more accurately and to know which techniques to use for assessing cold-hardiness levels at different times across the season.

While designing the study to answer this question, we reviewed a range of current methods for imaging plant tissues, assessing them for their ability to capture freezing events inside an intact bud. Thermal video recording offers only a surface view of freezing progression, as do electric thermometers, or thermocouples, which only register temperature changes at a specific location. MicroCT (computed tomography) scans offer great resolution of internal tissues, but cannot track freezing, as the method does not detect a contrast difference between liquid water and ice. Magnetic resonance imaging (MRI), however, can detect this difference. Searching the UW campus for appropriately-sized MRI machines, I found one in use at the Small Animal Imaging Center. While a regular MRI has an entrance designed to fit a person, this apparatus was made for animals such as rats, with an entrance diameter of about 3 inches.

`I needed a device to control temperature with great precision, which I set out to construct.`

Once we found the proper MRI machine, we needed to find a way to control the rate of decreasing temperature at which the buds would have been exposed—a rate of vital importance. Studies have reported that a common rate of temperature change in nature is 1 °C/hr (degrees Celsius per hour). Thus in laboratory conditions, we usually work with rates ranging from 1 to 4 °C/hr, otherwise you risk creating artificial effects in non-realistic freezing conditions. To detect the progress of freezing in our plants, I needed a device to control temperature with great precision, which I set out to construct. The goal was to acquire MRI images corresponding to slices of our samples at room temperature, and then slowly decrease the temperature, capturing other images at just below freezing, and then two more times at colder temperatures, always of the same slices.

In collaboration with the Morgridge Institute's Advanced Fabrication Laboratory,—a.k.a. the "Fab Lab"—at UW Madison, we started to develop a prototype. It needed to follow several guidelines: it could not have any of its metallic implements close to the MRI apparatus, while at the same time it had to withstand freezing temperatures, exhibit chemical resistance, and not interact with the imaging process. The prototype needed to have three compartments: one for the flow of chilled glycol, a second for the addition of a chemical that helps with image contrast, and a third to surround the samples with all these compounds.

Once the design was defined, we started testing the circulating system. We located the circulating bath and pump for the chilled glycol with their metallic parts outside the room, connecting the glycol via tubing with the prototype inside the MRI. With this circulation system exposed to air, frost formation was also a big concern, as this could damage the expensive MRI equipment. We ran trials in our lab just to see where frost was forming and find corrective measures.

By this time, a year had passed, and finally, we were able to obtain our first images. After doing the official runs in late fall of 2019, I measured the signal intensity at different regions of the buds and compared them across the different imaged temperatures. Higher signal intensity translated into a higher presence of liquid water, and the opposite meant relocation or freezing of water. My analysis showed a gradual decrease in the amount of liquid water in the internal tissues of the bud. This was an important piece of evidence for our study. With the MRI, we observed a range of freezing events occurring at temperatures below -20 °C, while in visual damage evaluations for that same date, we found that damage did not start until reaching temperatures of -24 °C and lower.

In the end, our study concluded that terminal buds of cranberry survive exposure to freezing temperatures by undergoing a process of freeze dehydration, a variant of the extraorgan freezing survival strategy. From here, we can direct our efforts on developing cold hardiness models with a greater understanding of the damage patterns, knowing what mechanisms need to be developed during the fall during the seasonal acclimation to winter. This knowledge will help farmers and horticulturists decide how to respond when fruit crops are exposed to the threat of unseasonably cold temperatures—conditions likely to occur with greater frequency as climate change advances.

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Morus rubra

By Devika Jaikumar

In the summer heat, mornings are blanketed by a mist that leaves the arboretum quiet and still. I softly make my way up Bussey Hill, my shoes soaked through by the morning dew that lies thick on the grass. A fawn suns itself on a patch of dirt while a family of turkeys take their morning stroll, all undeterred by my presence. It isn't these creatures I have come to see, however, but 787-85*A, a striking mulberry tree that every morning for the past two weeks had been picked clean of fruit by squirrels.

Found all over the world, mulberries are known for their sweet fruits that resemble blackberries, and for their role as a key food source for silkworms. The tree I visited nearly every day for a month is a specimen of *Morus rubra,* a species native to North America. At the Arboretum it is surrounded by *Morus alba* trees, a species introduced from Asia. Despite their differences—glossiness of leaves, presence of hair-like structures on the underside of leaves, colors of fruit—these species are prone to hybridization, making positive identification of trees especially complex.

My goal in the summer of 2021 was to acquire a cutting of the plant, with leaves and fruit, to press for an herbarium specimen. As I approached the tree that morning as I had so many times before, the squirrels leaped off, revealing that they had picked the branches clean of ripe fruit. I could not fault them for their behavior; the idea of explaining to the council of squirrels how I needed a handful of fruits for scientific study was enough to keep my spirits up until the day I was successful in my task.

The specimens that I was finally able to collect were sent to Morris Arboretum, where researchers are engaged in long-term study of mulberry hybridity. Herbarium specimens have been crucial to research for centuries, and one of their primary uses is to identify species. While we believe our multi-stemmed Bussey Hill tree is correctly identified as *Morus rubra,* perhaps it is indeed a hybrid, the identity of which has taken years of growth to reveal itself.

Herbarium specimens also fill gaps in our knowledge by creating a physical timeline for plants throughout their lifespans. When I collect a specimen to later mount onto paper and file into the Arnold Arboretum's Herbarium of Cultivated Plants, it's with the knowledge that this specimen is intended to last hundreds of years, to be used in ways that I can't even imagine. As for the squirrels, their interest in the mulberries is far less mysterious.

Devika Jaikumar is a curatorial assistant at the Arnold Arboretum.

Photograph by Michael S. Dosmann

ANTHROPOCENE

Oak and Pine in Life and Death

By Robin Lee Carlson

In *The Cold Canyon Fire Journals: Green Shoots and Silver Linings in the Ashes,* artist and naturalist Robin Lee Carlson shares the six years she spent learning from the wildfires that burned through Stebbins Cold Canyon Reserve near Davis, California twice in five years. This excerpt, drawn from the chapter “The Relativity of Time,” explores the tree-entangled life that returns in abundance after fire—some of which emerges rapidly, and some of which takes longer to make itself known. “It is tempting to immediately tally the living and the dead,” notes Carlson. “But trees exist on a very different time scale, and their lives and deaths caution against hasty conclusions.”

Excerpted from *The Cold Canyon Fire Journals: Green Shoots and Silver Linings in the Ashes,* by Robin Lee Carlson. Published by Heyday, 2022. All rights reserved.

“Look at this burned bay laurel. Do you see the way those branches are all pointing the same direction?” Dead tree branches just over my head etch lines into the electric-blue sky, and I am transfixed. From the thicker supporting branches to the finest twigs, they all swirl in the same direction, performing a ghostly dance choreographed by the Wragg Fire’s fierce, hot wind.* Even though the air around me is completely still, I can easily

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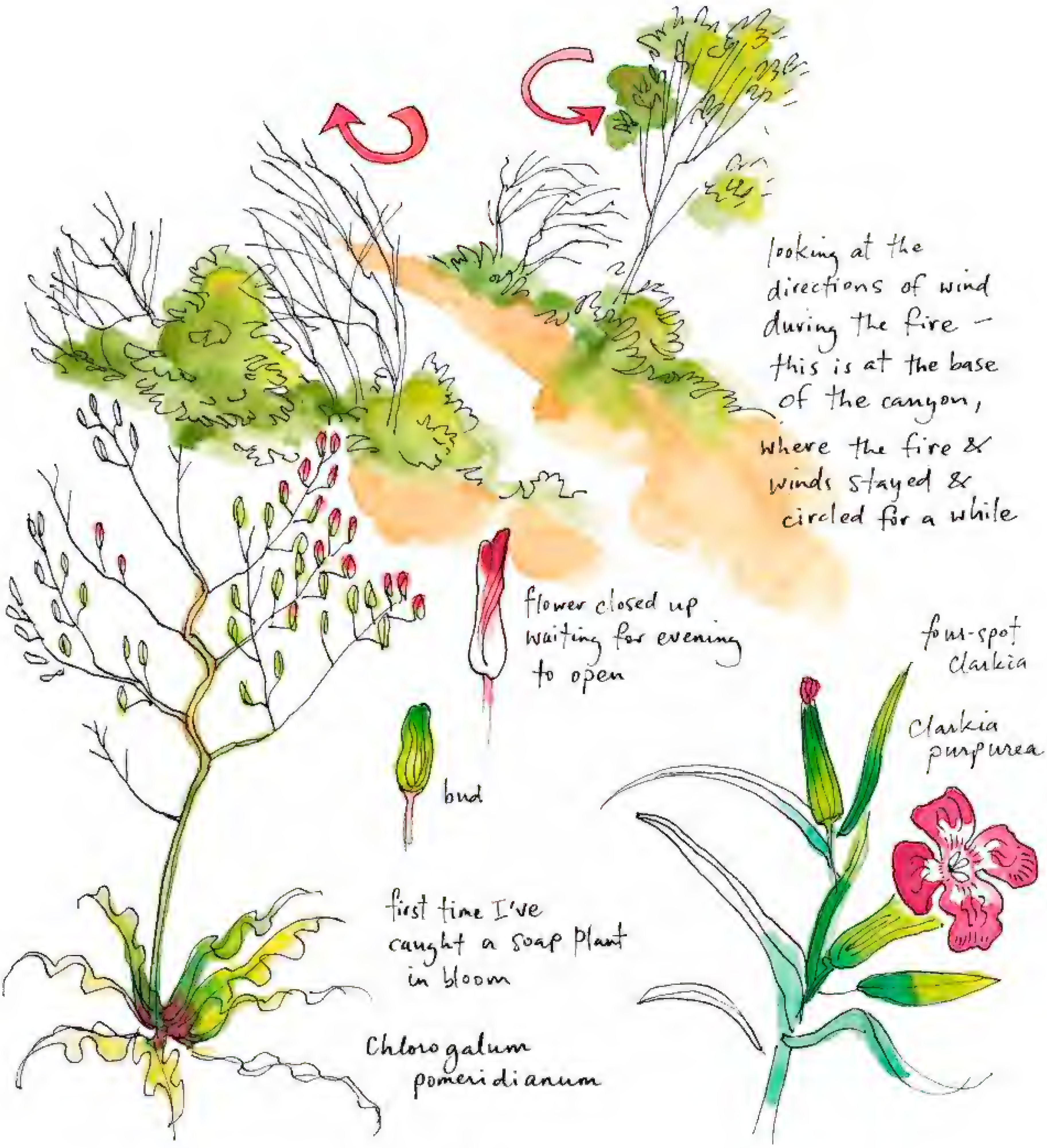
* Ignited when a car exhaust sparked dry grass near Napa County’s Lake Berryessa, the Wragg Fire burned some 8051 acres between July 22 and August 5, 2015.



looking at the directions of wind during the fire – this is at the base of the canyon, where the fire & winds stayed & circled for a while

flower closed up waiting for evening to open

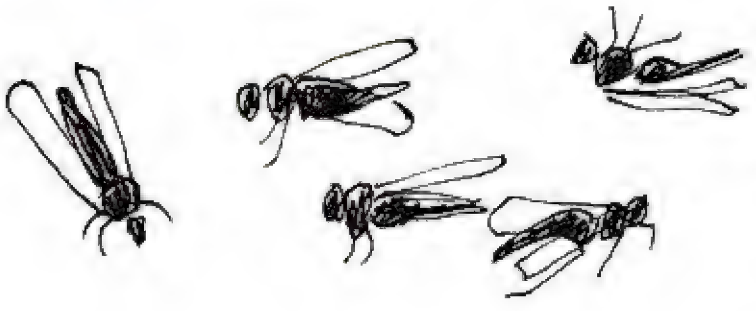
bud

four-spot Clarkia

Clarkia purpurea

first time I've caught a soap plant in bloom

Chlorogalum pomeridianum



small flies that were all over the buds & closed blossoms of the soap plant envision the wind whipping around these trees as the fire blazed and they were frozen in this shape.

It has been a year-and-a-half since the fire, and a participant in a field sketching class I am leading at Cold Canyon has just pointed out these shapes in the trees to me. Miriam Morrill is a biologist and a specialist in fire and communications at the Bureau of Land Management (BLM). She is also an artist, and I see that she has been making notes and drawings in her sketchbook that capture some of the signs of fire behavior still legible in the landscape. This is not a language that I know, and we are excited to compare notes.

She explains that she sees more trees and tree skeletons on Blue Ridge than she would expect had the fire advanced up that slope from the bottom of the canyon. She surmises that the fire instead came from the west, over the top of the ridge, and backed down into the canyon, burning less intensely moving downslope than it would have had it been charging upslope. I tell her that this is what I know to have been the case, based on Jeffrey Clary's descriptions of the fire's progress. Miriam says that she also notices that the branches of the leafless trees where we are standing near the creek are all pointing in different directions, as if different eddies of wind were whirling around each one. From this, Miriam concludes that the fire became more intense at the bottom of the canyon before racing up the slope on the other side. As the Wragg Fire paused here, the intensity of the fire created its own weather.

Strong winds gusted and eddied among the folds and pockets of the hills. Where the fire did not fully burn the vegetation, its heat dried out the branches. Losing their moisture made them permanently inflexible, pointing in the direction of the last wind they would ever feel. This phenomenon is termed *foliage freeze*. Time stopped, arrested, and I am held there too, caught in this still, quiet day but also in the midst of the roaring frenzy of fire and wind of late July 2015.

This could be the image of violence preserved, jarring me out of time on a peaceful day. I might see this as the life force of these trees sucked right out of them by the wind, with their macabre skeletons still here to remind me. If fire is only a catastrophe from which this ecosystem must recover, the brutality of that image is appropriate. But if fire's place in the ecosystem is subtler, then those frozen branches might equally be seen as a reminder of the continuity that underlies the fire, tying the seemingly singular event to the past and future of the landscape.

Disturbance has a past and a future and blends more easily into both than it would seem. And now, as I stand here in the present, the frozen branches are important clues to the behavior of the fire. Fire leaves signs behind on the land that are often fleeting—erased by wind and rain and footsteps—so it feels like a race to find and read them before they disappear. Patterns of ash and char, curled leaves, fallen tree trunks, and grass stems—all are quickly obscured by the movement of animals, the fall of rain and rush of wind, and the growth of new vegetation. These twisted branches, though, remain. The fire's passage is frozen in the trees' bodies, and the trees' writhing limbs marking this path are emblazoned on my mind.

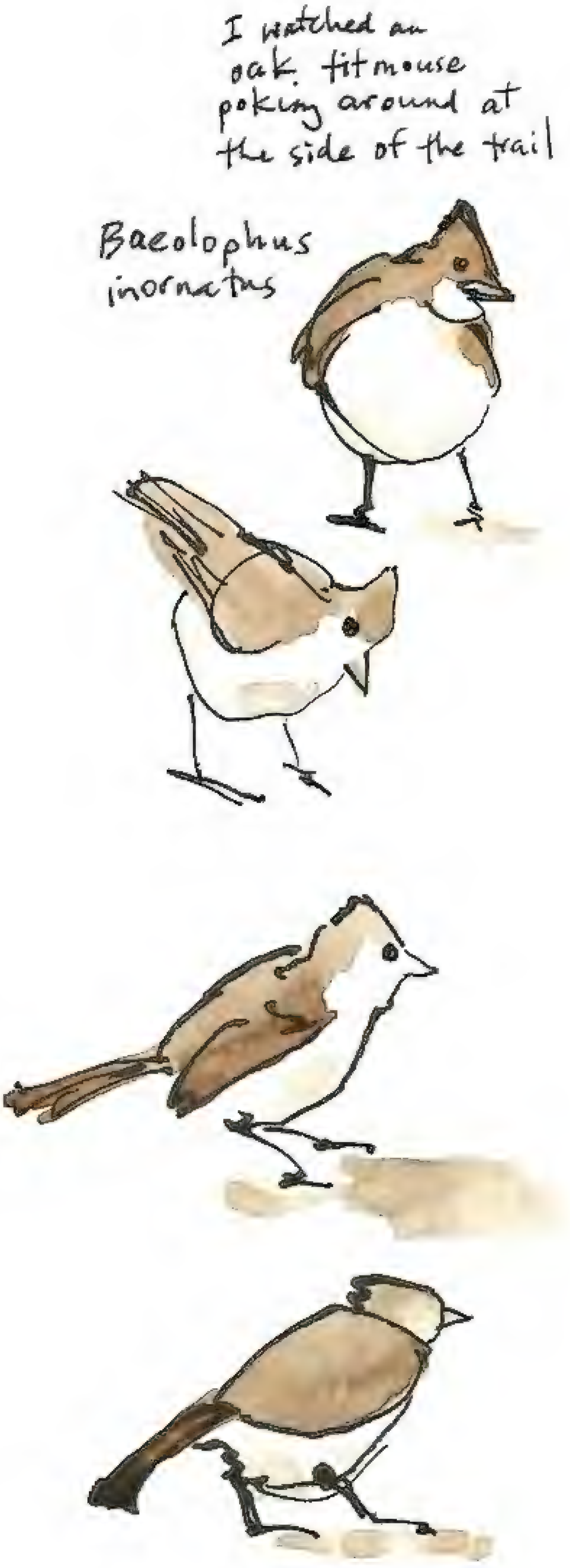
Oaks: Anchors in time

Growing up in California's Central Valley ensured that water worries indelibly marked my subconscious. I am a child of brown summers and green winters, of regular drought and water scarcity. I was a toddler during the 1976–77 drought and have vivid memories of my mother explaining to me why we couldn't flush the toilet every time we used it. Even as a child, I approached each winter with concern: Will there be enough rain this year? Will the rivers dry up? I find nothing more reassuring than rain and nothing more terrifying than the endless cloudless summer skies.

As I got older, I began to understand the ways life here has adapted to make the most of the rain we do receive. I am reassured by the hardy species that get by on little water and conserve their moisture in ingenious ways, like the blue oaks standing tall in the woodlands and savannas that ring the Central Valley. These are important members of Cold Canyon habitats, the trees that Jeffrey was concerned about after the Wragg Fire. Blue oaks are of middling size for oaks, with the wildly crooking branches common among oaks that make their limbs look as though they are dancing ecstatically. Their leaves are compact, with only wavy margins, not the deep lobes of some of the other oak species. The waxiness of their leaves helps with moisture retention in their often-arid habitats.

Staunchly Californian, blue oaks are endemic here—found nowhere else in the world. They live at lower elevations in the Coast Ranges and the Sierra Nevada, as well as on the southern end of the Cascade and Klamath Mountains. A few grow in the Central Valley itself, but they mostly prefer to be up in the

Illustrations by Robin Lee Carlson


I watched an oak titmouse poking around at the side of the trail
Baeolophus inornatus

hills. Though I live in the flatlands of the valley, I am glad to be close to the hills and mountains, and it is to these foothill habitats that I turn for guidance in how to live in an often-parched land.

Of all the deciduous oaks in California, blue oaks are the most able to withstand drought. Their taproot—their main central root—can grow deep into the ground to find the water table, to depths of eighty feet, though they can also focus their energy on growing shallower roots if water is available higher in the soil. They need soil that is relatively dry and well drained, and are found on soils that are poorer in nitrogen, phosphorous, organic matter, and other nutrients than the soils that support other California oaks. On these soils, they cultivate communities of other hardy species by holding the earth in place against erosion and using their taproots to bring water to the surface, incidentally making it available to other species as well. Before introduced annual species came to dominate California grasslands and savannas, blue oaks grew alongside bunchgrasses such as blue wildrye and purple needlegrass, similarly water-conserving species. The oaks and grasses mutually supported one another, sharing resources via fungal mycelial networks.

Now, introduced annuals such as redstem filaree, cheatgrass, and wild oat have largely replaced the bunchgrasses. The introduced species compete with young oaks for space, water, and light, just as they outcompeted the native bunchgrasses for these resources. As in the rest of their range, blue oaks in Cold Canyon shelter quite a few introduced annual species, but they are also home and sustenance to many other creatures. Nuttall's woodpeckers rely on them for foraging and nesting. Dusky-footed woodrats build at their feet and eat their acorns. Fallen branches are important gathering places for western fence lizards. Oak titmice—birds the soft mousy brown of their namesakes—defend year-round territories in their canopies.

It is easy to see the wildlife that depends on the oaks, but equally important to understand the less visible forces at work. Blue oaks are critical to the quality of the soil around them, increasing its nutrient content. This is thanks to the fall of leaf litter, which increases the nitrogen in the soil. It is also because trees capture moisture from the air that otherwise would have evaporated. Instead, the water droplets adhere to the leaves,

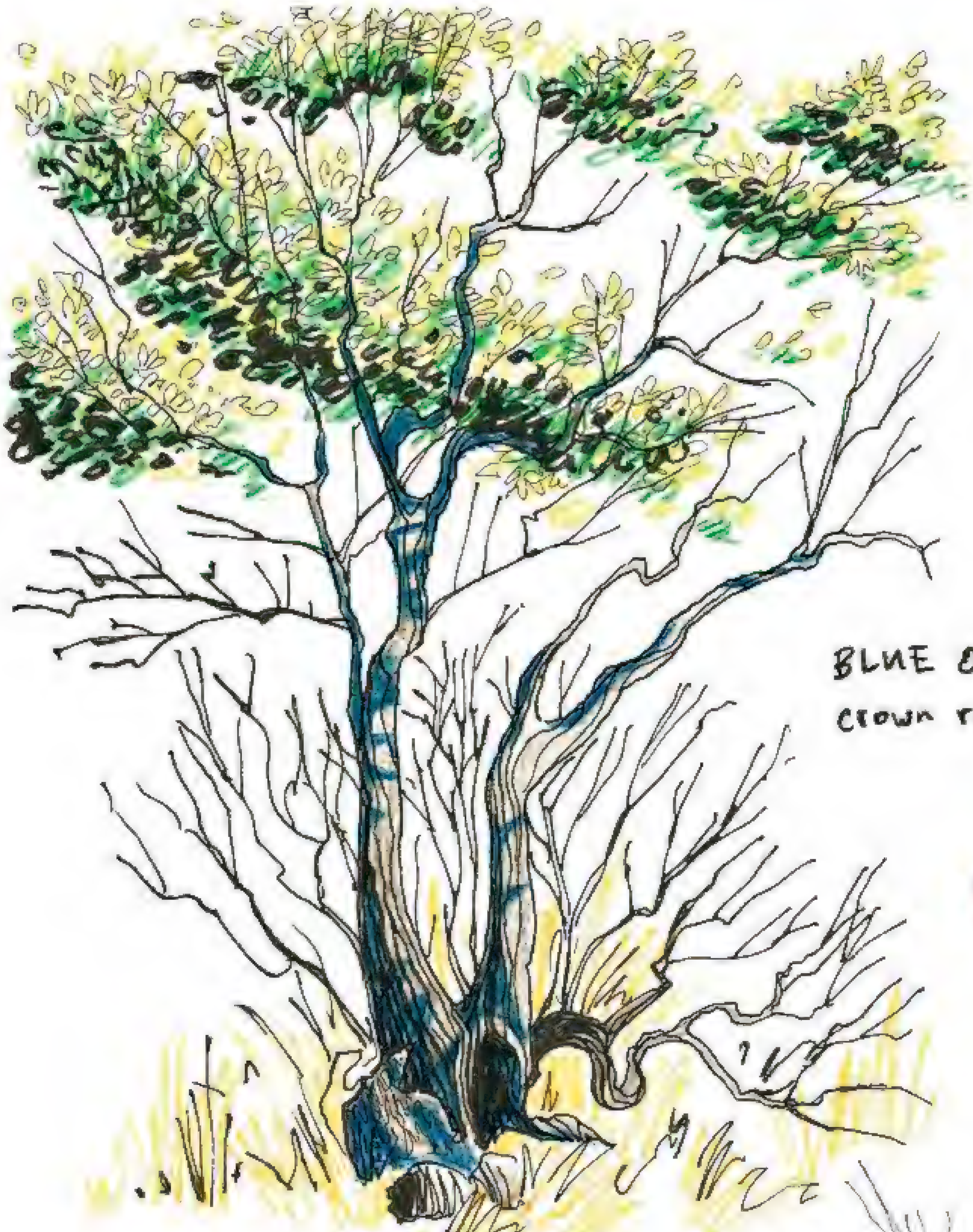
the fallen blue oak
after high winds

ladybug pupa

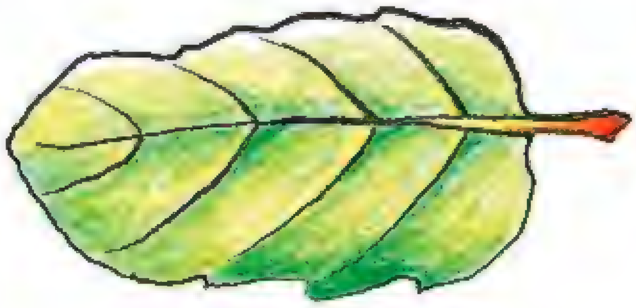
mating
ladybugs

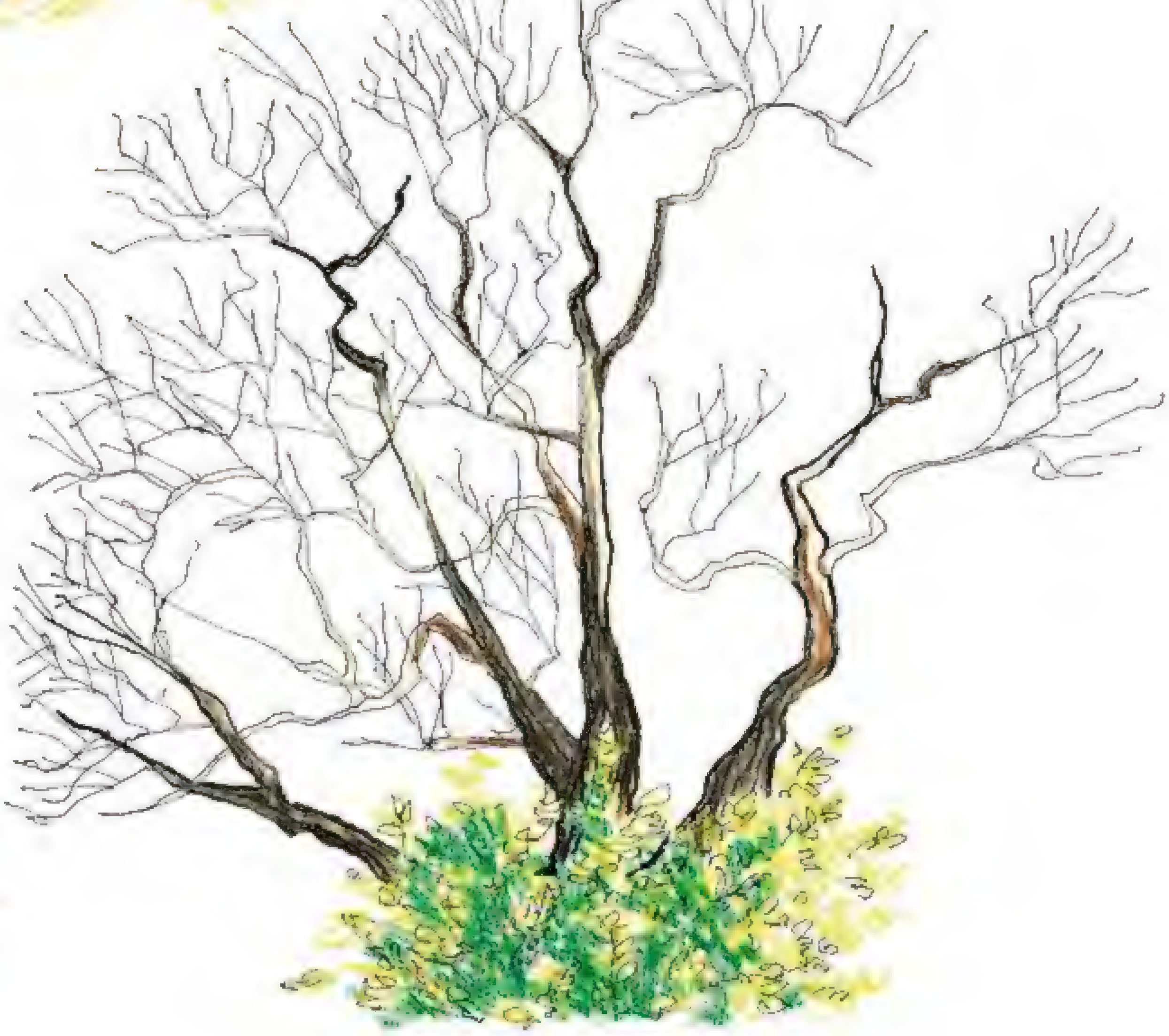
Coccinellidae

more examples of swirling winds
in the fire



BLUE OAK Quercus douglasii
crown regrowth - epicormic sprouting





Quercus wislizeni

INTERIOR LIVE OAK
basal sprouting

eventually aggregate into larger drops and then fall to the ground. The drops bring along important nutrients—potassium, phosphorous, and magnesium, for example—that were present in the air and are concentrated when the drops form.

There are three kinds of oaks growing in Cold Canyon, two of which are trees—blue oak and interior live oak—and scrub oak, which takes a shrubbier form. Interior live oaks tend to be found in the bottoms of the canyons, as they prefer the wetter areas in the riparian zones, and these are often too wet for blue oaks. Blue oaks generally grow on the hillsides. The distinctions are not absolute: there are certainly blue oaks growing in the canyons and live oaks on the hills, but the general pattern holds.

Over the five years of my visits, when I look closely at oaks, I try to decipher the puzzle of their health and survival. In a landscape of rapidly sprouting annual plants and fast-growing shrubs, trees are not as easy to assess. There are no immediate answers to how the oaks at Cold Canyon are faring. In the areas closest to the creek, some oaks did not burn at all and are doing fine—these are mostly interior live oaks. A little further from the creek, there are more interior live oaks, and some of these burned. These that burned are sprouting, strong shoots growing up from their bases, from their root crowns. The brand-new leaves in their chartreuse skin are spiky and fresh. Further up the slopes, some of the blue oaks are sprouting. On the blue oaks I see, the sprouts are not at the bases of the trunks but higher on the tree, on the branches. These differences are characteristic of the two oak species: live oaks tend to regrow from their bases, blue oaks from their crowns.

The oaks that are able to survive fires will benefit from them, especially if the fires were low intensity. Fire removes accumulated litter beneath the trees, which helps reduce the numbers of insect pests that feed on acorns, such as filbert worms and filbert weevils, two of the most common in California. Fire also helps remove some of the oaks' competitors for resources, such as annual grasses, though it can also open opportunities for other competitors—thistles, filaree, and the like—to gain a foothold and claim the open turf for themselves.

The world underneath the blue oaks' canopy is much different now than it was before incursions of plowing, plants, and livestock. Fire can still be a healthy force, but that is no longer always the case, now that fires burn hotter and higher, and more often kill the crowns of trees, making it hard for trees to survive and resprout. The bark of mature blue oaks is thinner than other similar oaks, which increases the trees' susceptibility to fire as they age. It is more difficult for acorns to grow under competition from introduced plants and in our rapidly drying environment, with droughts becoming more and more common.

All of this is to say that one year, three years, five years in, it is too early to tell how the oaks are doing at Cold Canyon. Trees challenge our impatient animal desire to know what is happening. Acorns take a very long time to make more acorns. Seedlings take a long time to become saplings, which take a long time to become mature trees. Time stopped for the branches frozen by the heat of the fire, but most of those trees are still alive and sprouting green at their bases. Trees live and die slowly, but it is difficult to remember this in the context of a disturbance like wildfire. The fire can feel like a catastrophe, and tallying the damage afterward feels so urgent. Trees move in their own time, and it is hard for me to comprehend when I am so quick, so mobile, so unrooted.

Oak gall wasps

Sometimes I go hunting for marvels, and sometimes they are sitting right in the middle of the trail, in shocking bright-pink glory. On a day when I arrive at Cold Canyon planning to focus on oak regrowth patterns, it is a strangely appropriate gift to find a crackly, dry blue oak leaf in front of me, covered in tiny galls. There two different kinds of gall on the leaf, both elaborately structured and very pink. I pick up the leaf and sit down on a rock beside the trail to wonder at the details of these tiny homes, nurseries to the microscopic babies within.

The interaction that creates these intricate structures is an amazing tale of manipulation, and a relationship maybe even more strange than the complex interaction fostered by horntails, fungi, and the distressed trees in which they lay their eggs.* Once again, it is wasps that are responsible. This time, very much unlike the large, somewhat alarming horntails, however, gall wasps are no bigger than about a quarter of an inch. Some of the smallest gall wasps in the world are only one millimeter long, the size of a comma on this page.

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* In Chapter Two, "First Responders," Carlson describes how horntail wasps (family Siricidae) are some of the first insects to arrive after a fire, drawn to the distressed trees in which they will deposit their eggs—along with symbiotic fungi that break down the wood upon which their larvae will feed.

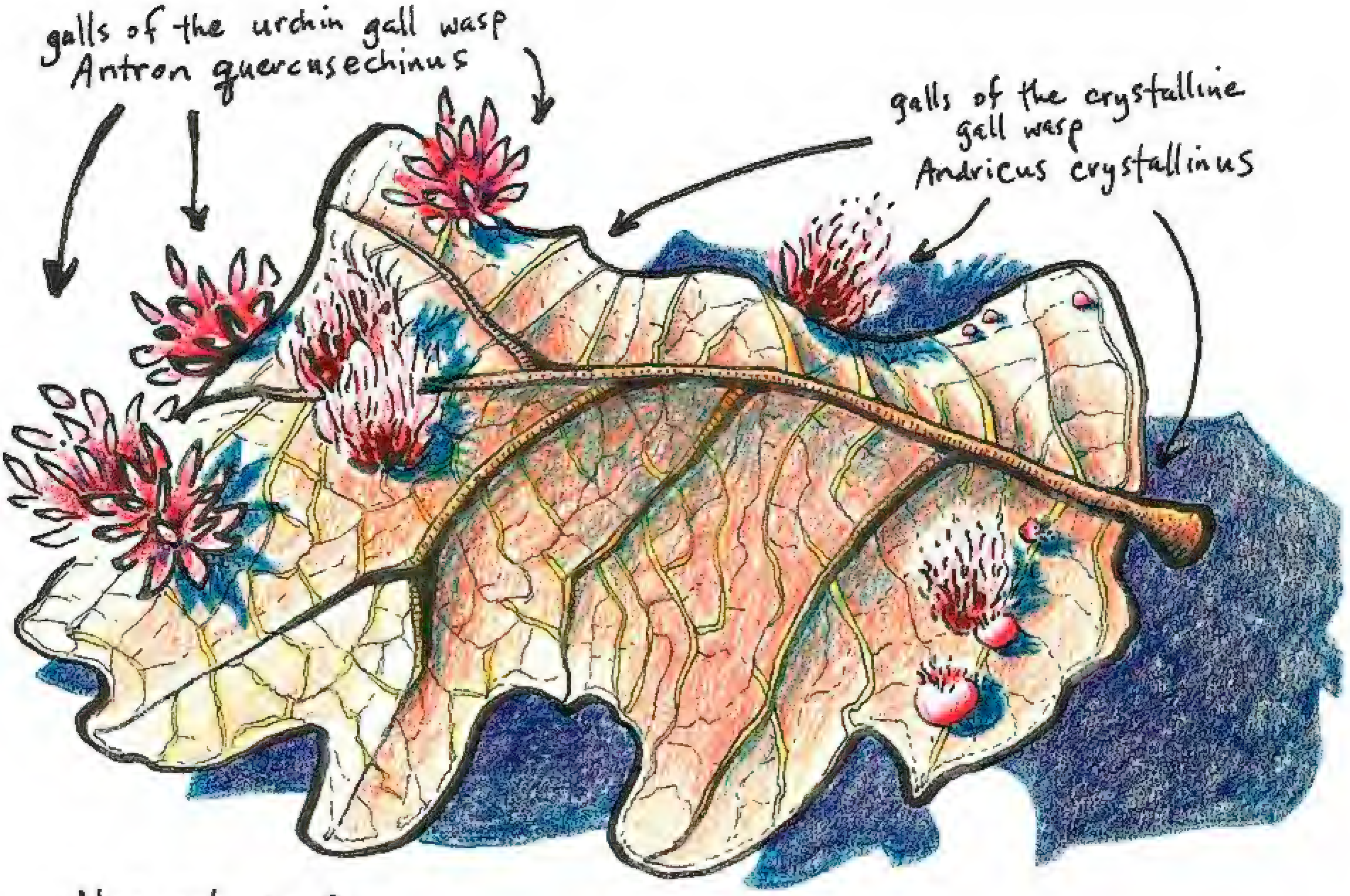
Trees move in their own time, and it is hard for me to comprehend when I am so quick, so mobile, so unrooted.

Female gall wasps lay their eggs in rapidly growing parts of trees, such as twigs or leaves like the one I am holding in my hand. Once the eggs hatch and the wasp larvae begin to eat the plant tissue, a chemical in their saliva, or perhaps the mechanical process of their feeding itself, stimulates the plant to redirect some of its own cells to produce a protective outer structure that surrounds the larvae. This is a defense response by the plant, sequestering the larvae so that they do not eat its other parts. But it has great benefits for the larvae as well. The gall is both shelter and, inside, more food for the ravenous larvae, which comfortably feed until they mature and chew their way out of the nursery as adults. It does not seem as though the wasps do any real harm to their host plants, though they do of course consume some resources that would otherwise be used to meet the plants' own needs.

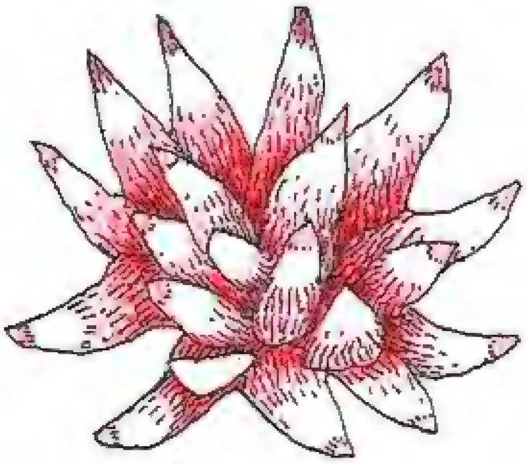
What is most amazing, and apparent even on the leaf I've just found, is that each species of gall wasp stimulates a very specific and unique structure of gall. One of the kinds of gall on the leaf has spines sticking out in all direction. This is the home of a batch of urchin gall wasp larvae. The other kind is almost furry, and is made by crystalline gall wasps. The gall shapes are even expressed in the wasps' scientific names. The urchin gall wasp is *Cynips quercusechinus*—the species name means "oak hedgehog," emphasizing its spikes. The crystalline gall wasp is *Andricus crystallinus,* inspired by the delicacy and translucence of its fine "hairs." Two different species, with two characteristic gall shapes. And there are over a hundred different gall wasps known so far worldwide. How on earth do the chemicals in the saliva of the larvae dictate the *shape* of the gall that the plant cells will build?

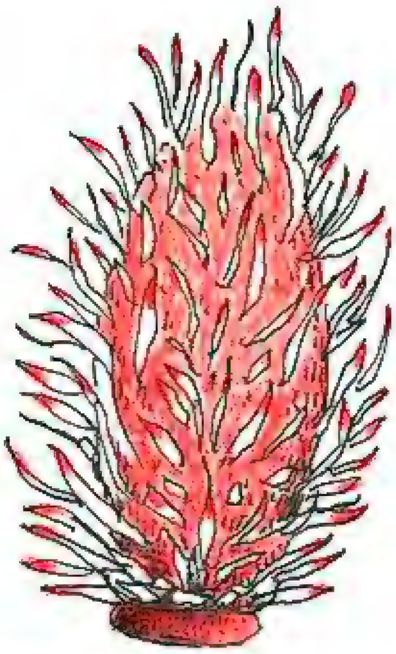
Most gall wasps are specific to a single type of tree, usually an oak. It turns out that blue oaks have the largest known number of different gall wasp species, at forty-one and counting. They also appear to have the greatest diversity of shape and color of galls. I am looking at the galls just a little after one year since the fire. I try to guess which of the blue oaks around me dropped this leaf. I wonder whether it was a tree that burned, and this was a new leaf since the fire, or one that survived the fire intact. Perhaps the wasps whose offspring were reared in these galls came to Cold Canyon after the fire, or perhaps they survived the fire as larvae themselves.

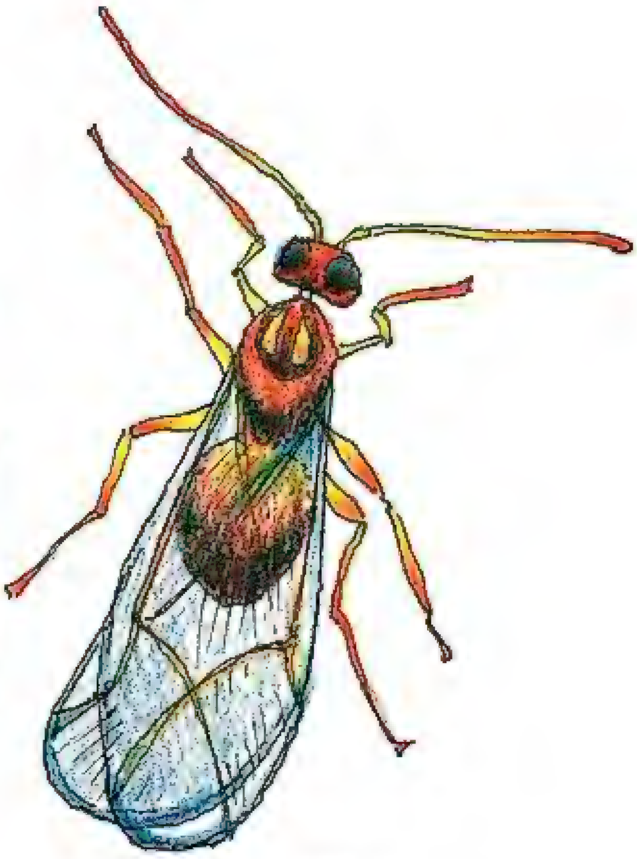
The effects of fire on oak galls have not been extensively studied, but it appears that gall wasps need time after a fire to return. There must be oaks


galls of the urchin gall wasp
Antron quercusechinus
galls of the crystalline gall wasp
Andricus crystallinus

blue oak leaf
Quercus douglasii
fallen leaf spotted right in the middle
of the Homestead Trail


URCHIN GALL
Antron quercusechinus


CRYSTALLINE GALL
Andricus crystallinus


Andricus sp.

for them to return to, either newly grown oaks or ones that survived the fire. There must be sources near the burn for them to come from. And some wasp larvae surely survive the fire, sheltering in the oaks that did not burn and remained cool enough that their leaves were not all killed by the heat. Adult wasps are not likely to survive the fire themselves, but then, they generally live only about a week, so the wasp truly spends most of its life—about a year—as a larva.

How funny it is that wasps have twice been my windows into the endlessly intricate webs of interactions that compose these ecosystems. First, the horntails, who rush to burned trees to lay their eggs and inject their symbiotic fungi. Now the gall wasps, who bend the oaks to their will but are dependent on their hosts for shelter and protection when the world around them burns. Without being present in these places—burning and burned—I would have remained ignorant of these beautiful mysteries. The wasps' relationships are just glimpses into vast silken webs of stories that humans have not yet even dreamed. Start traveling along just one exposed thread, and how many more nodes in the silk might we find? The ones we do see tantalize us with the many that are yet unknown.

A gray pine too damaged by fire will not grow back.

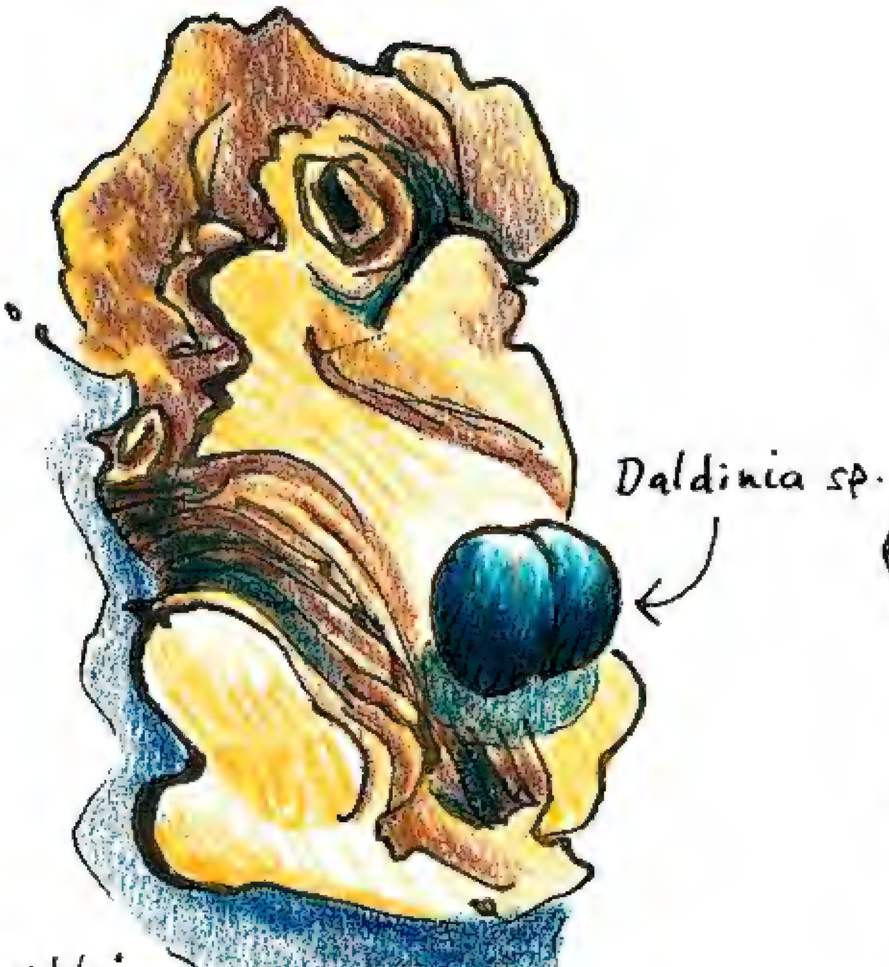
Gray pines: Waves of loss and return

Gray pines, towering over the other trees at Cold Canyon, seem to me the embodiment of solidity and permanence after the fire. They have an underappreciated beauty, being arguably rather spindly and dull in comparison with some of the more majestic pine species. But I think their long, pale-green needles are pretty, especially in the bright summer sun. And while their needles are not densely packed enough to create a whole lot of shade, I find they create striking silhouettes against wintery overcast skies. In the early years after the canyon burned, I am anxious to count the survivors and the lost, to take inventory, even if anecdotal, of the fire's casualties. Studying the gray pines, I can see green needles on what look like two-thirds of them, so I assume they have survived fairly well. But on a winter hike with Jeffrey Clary and Sarah Oktay, the Reserve's current director, just over three years after the fire, I learn that the truth is likely more complicated.

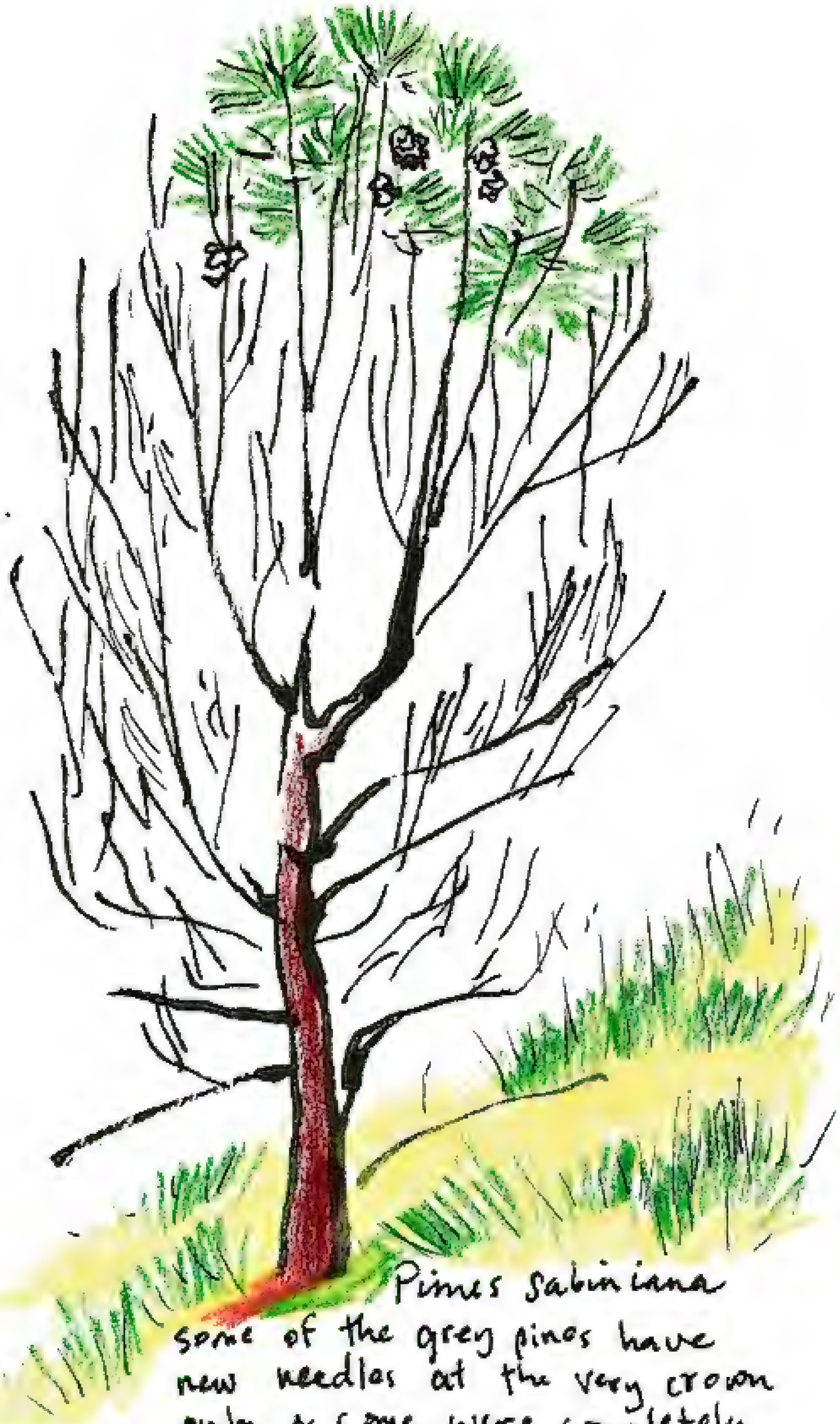
Gray pines, also known as foothill pines, are often found in the blue oak woodlands and savannas that are interspersed with chaparral habitats in the California foothills. Like blue oaks and chaparral shrubs, they are hardy and thrive in places with drier climates and less nutrient-rich soils. Unlike many other plants, they do not have root, trunk, or bark adaptations that allow them to survive fire. Gray pines are extremely pitchy, even for a pine. They are torches in a fire, thanks to the resin in their needles, cones, bark, and wood. Because they do not contain the burls or other root structures that allow many chaparral shrubs to regrow, a gray pine too damaged by fire will not grow back.

Instead, gray pines must start all over again, growing from the seeds protected inside their enormous, spiny cones. I see cones, open and dry, with seeds long spilled, all over the canyon. Picking them up and turning them in my hands, I wonder whether their seeds are unfurling now, nestled underground where they landed after dispersing when the cone opened still high on its tree. The heat of fire stimulates germination by weakening or breaking the seed's coat and allowing it to begin development. Gray pine seeds are also able to germinate without fire, but there are other pine species, such as lodgepole and knobcone, that do require fire for germination, at least in some parts of their ranges.

This all sounds reasonably straightforward: gray pines mostly die in fires and eventually return to the landscape as new sprouts. It is the timing of their


Daldinia sp.

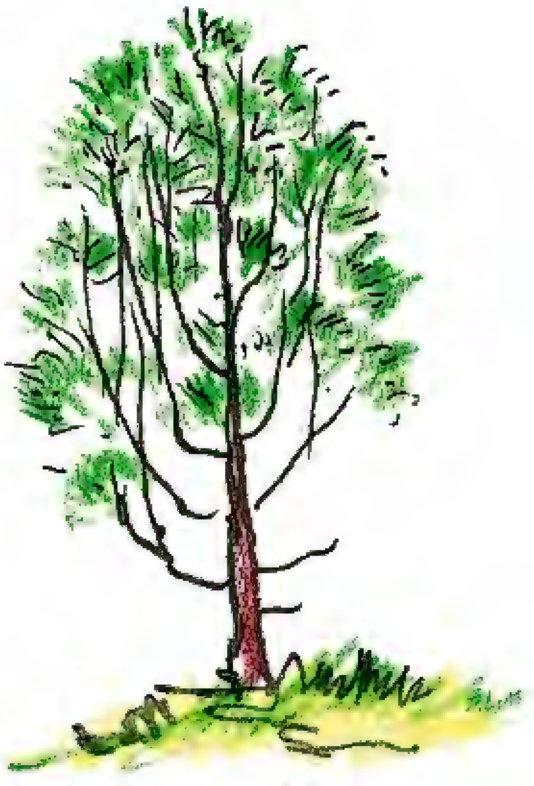
sitting
on a rock in the trail:
fallen wood from oak



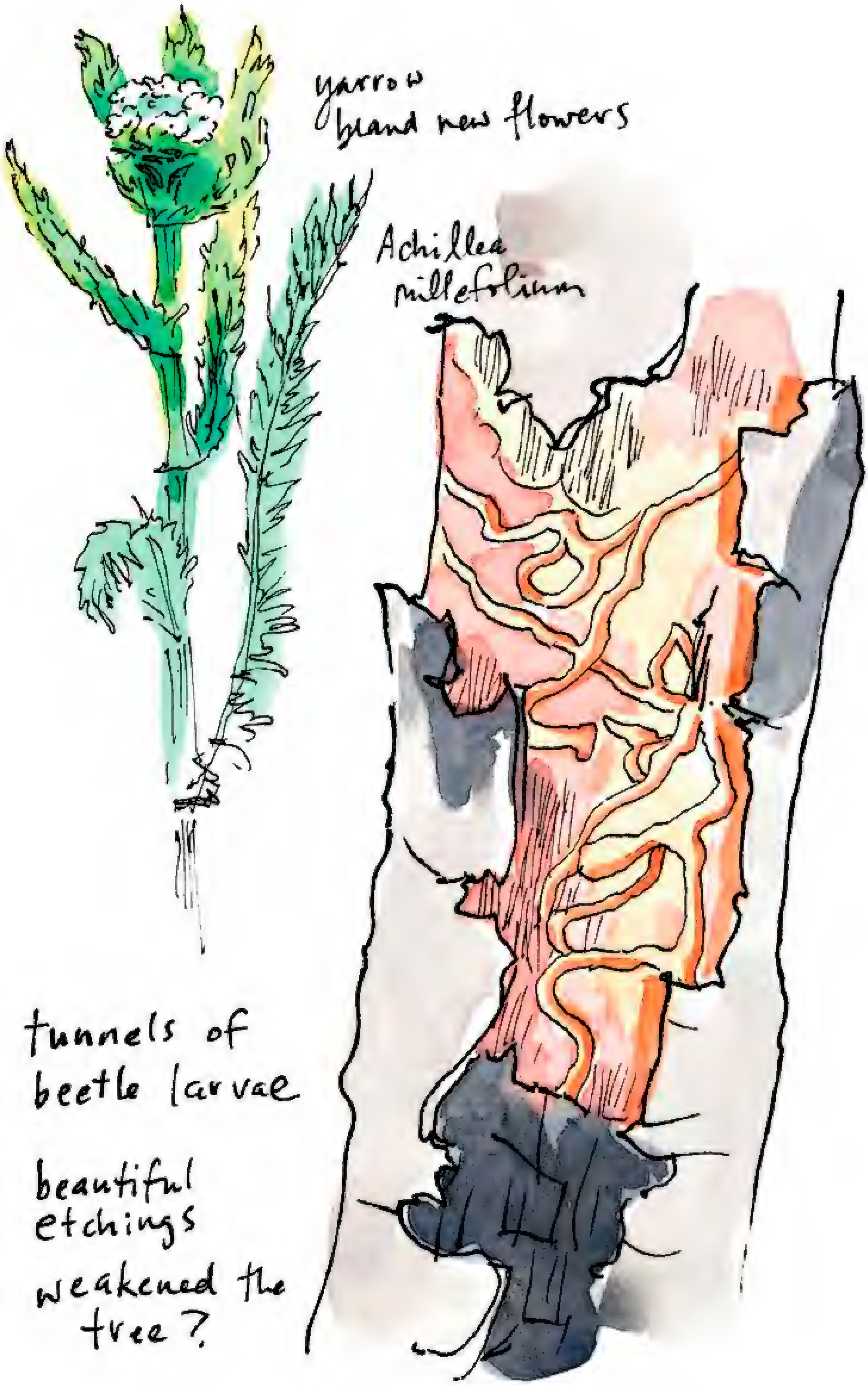
Pinus sabiniana
some of the grey pines have
new needles at the very crown
only & some were completely
killed

toyon at the creek
crossing has berries
(resprouting toyons
elsewhere
do not)

completely bare
of new needles



new needles over
entire tree


yarrow
brand new flowers
Achillea
millefolium
tunnels of
beetle larvae
beautiful
etchings
weakened the
tree?

dying that is a surprise. Jeffrey points out that even though many of the trees at Cold Canyon still have green needles in their crowns, they may already have been killed by the fire, either because part or all of them burned or because the heat of the fire was too great and killed their tissues. Set inexorably onto the path to their fate, they are continuing to function while slowly winding down. In their diminishment, they are now home to organisms that they would have easily fought off while healthy. The fire drew pine sawyer beetles—a kind of longhorn beetle—and their larvae are now tunneling through the pines' wood. Bark beetles, such as pine engravers, will also have come, finding nourishment in the wood of the dying trees.

These wood-boring beetles and their relatives are usually healthy members of forest communities, consuming only trees that are already dead or dying and returning the trees' nutrients to the ecosystem. But in the increasingly stressed habitats of the western US, some species, such as the pine engravers, have become decidedly unhealthy. In the face of plentiful dead wood during years of drought and fire and excessive logging, the beetle populations explode. Voracious new generations feast on living trees too, making for even more fuel in wildfires and escalating the vicious cycle. While we are most familiar with large expanses of dead pines and firs in the Sierra, gray pines are not immune to these amplifying effects of climate and beetle. As I walk beneath a pine with silvery-green needles left on only a few of its higher branches, I see the fine line between health and disease, between beetles as beneficial recyclers and beetles as forest destroyers.

I am learning that dying is a completely different phenomenon for a tree than for all of us more ephemeral creatures. It is not a single event in time but a very long process. How smooth is the continuum of living and dying and how hard to say where some organisms are on that spectrum.* There are no quick answers in assessing the results of upheavals like wildfire, at least for trees, as I watch the aftermath play out slowly over the years.

Gray pines are common in chaparral habitats, but they require plenty of time to recolonize between wildfires, after the fires have mostly killed off the existing trees. On the one hand, if wildfires occur too frequently in chaparral, there will not be enough time for new gray pines to grow from seed. As the window for recolonizing closes, gray pines will slowly disappear from these habitats. On the other hand, if fire is completely absent from the chaparral ecosystem, gray pines will take over—enough gray pines will eventually colonize that the blue oaks cannot compete for space and sunlight. Fire—at least a healthy fire regime—keeps the balance in these blue oak and gray pine foothill habitats.

After my hike with Jeffrey and Sarah, before I head home to the valley flatlands, I stand next to a gray pine and put my hand on its bark. Time slows to a crawl as I deliberately calm my quick animal breaths. Time stops while I try to think in tree time. Here time is measured in roots creeping, tunneling, and connecting with fungal mycelia and other roots. Time passes in rings of wood expanding, thickening, drying, and cracking into bark. And time is the slow, slow pull of senescence, embarked on long before the tree's final end. Senescence is set to the tiny music of the jaws of beetle larvae scraping and gnawing their intricate way through the tree, just below the surface of the bark.

This is a kind of sorrow, deep and abiding. There is nothing that will stop the onward pull of time and the tightening of death's grip. The last green needles will brown. The wood will fully dry. The tree will continue to stand for a long time, entirely dead, waiting for the gust of wind or shift of soil that will send it crashing to the ground. But I am also, just as deeply, moved by the cycles in which the pines and I are enveloped. As though my awareness of the process allows me into the rolling pattern. Nothing is what it once was, nothing in the view ahead of me can stay this way forever, and we are all senescing even as we are full of life.

The gall wasps whose tiny homes I marvel at on blue oak leaves live only a week as adults. A blink of an eye. What would they make of my ponderously long and slow life, beyond the limits of comprehension? Just as I struggle to understand how a living tree can also already be dead.

* For more on how trees blend of life and death, see Peter Del Tredici, "The Roots of Rejuvenation," in this issue (page 30).

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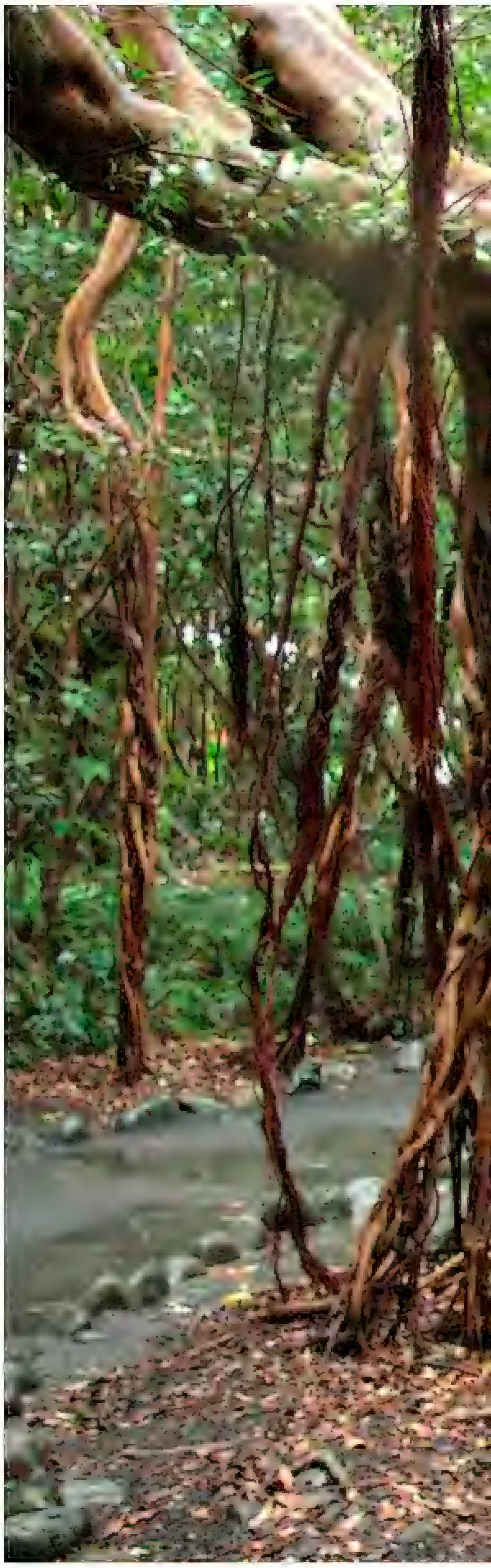
TREE TIME

The Roots of Rejuvenation

By Peter Del Tredici

I've been studying how trees can rejuvenate themselves through sprouting since 1989, when I traveled to Tianmu Mountain in eastern China to study a wild population of *Ginkgo biloba* and discovered that many of the ancient specimens growing there had produced secondary trunks in response to storm damage, logging, or landslides. Twelve years later, I published a review article describing the morphological mechanisms that temperate trees have developed for generating basal shoots following traumatic disturbance, from root suckers and branch layers to stump sprouts and lignotubers. Essentially, sprouting is a form of clonal growth that not only allows woody plants to recover from damage but also to circumvent the ravages of aging, especially when they are able to produce new, *adventitious* roots to support their new shoots.

In botanical sciences, the word adventitious is traditionally used to describe a plant structure that is somehow "out of place," such as a shoot produced by a root, or a root produced by a stem. Within the field of plant propagation, the term is used to describe roots produced by detached stem cuttings treated with auxins under greenhouse conditions. Intact trees growing in natural habitats also produce adventitious roots from their stems, either as a genetically programmed part of their normal development—such as the free-hanging aerial roots produced by tropical trees like strangler figs and mangroves—or induced by changing environmental conditions such as partial uprooting or burial with silt following flooding. Regardless of whether they are programmed or induced, adventitious roots always develop from cells that neighbor vascular tissues located just below the bark (Bellini et al. 2014).



Aerial roots on an ancient specimen of Chinese banyan fig, *Ficus microcarpa,* growing wild on the Japanese island of Yakushima. *All photos by the author*

Types of Adventitious Roots

My research has shown that the trunks and branches of intact temperate trees can produce five different kinds of adventitious roots, the most common of which are those that develop on low-hanging lateral branches that come in contact with soil—a process known as *layering.* The phenomenon has been documented in many different species of trees and is particularly common among conifers, both wild and cultivated. In many old estates, trees grown as widely spaced specimens often retained their lower horizontal branches that, under the influence of

age and gravity, ended up resting on the ground and taking root. Once they take root, the branches change from a horizontal to a vertical orientation and, over time, can form a ring of new trees surrounding the original parent trunk. There is an extensive literature on layering, which David Orwig of the Harvard Forest and I reviewed in 2017 in our article about this behavior in the eastern hemlock, *Tsuga canadensis*. Genera with species that commonly form layers include *Chamaecyparis, Fagus, Picea, Platanus,* and *Thuja*.

Lateral branches high up in the tree canopy also produce adventitious roots when they are covered with moisture-trapping epiphytes. As ecologist Nalini Nadkarni has shown, such "canopy roots" play an important role in nutrient absorption and cycling in tropical rain forests and, as described by Dietrich Hertel, to a more limited extent in temperate forests among such genera as *Acer, Alnus, Fagus,* and *Populus*.

In wetland habitats, the partially uprooted trunks of trees lying on the ground often produce adventitious roots that allow the prostrate stem to generate new vertical shoots, a phenomenon known as *trunk layering*. In a similar vein, the vertical trunks of trees that have been partially covered with soil, silt, or water after flooding often produce adventitious roots that allow them to adjust to the new conditions, as seen in species in the genera *Alnus, Larix, Salix, Sequoia,* and *Taxodium*.

Many trees produce swollen root collars with the capacity to generate adventitious roots as well as secondary shoots following some form of traumatic disturbance. In some long-lived species, these basal swellings—technically known as lignotubers—are a genetically programmed part of normal seedling development. In others, the they are induced by repeated coppicing or some other type of environmental disturbance. Examples of the former include species in the genera *Ginkgo, Eucalyptus, Olea, Sequoia,* and *Tilia* while the latter include species in the genera *Betula, Castanea, Morus, Platanus,* and *Quercus*.

As stated above, my interest in lignotuber-producing trees began with my studies of ginkgo trees in eastern China, where I observed that many of the ancient specimens growing on Tianmu Mountain had produced secondary stems in response to damage to their primary trunks. My research on lignotubers continued in California where the coast redwood produces massive underground lignotubers that, following logging, can generate "fairy rings" of new trunks that can extend the tree's lifespan for centuries (Del Tredici, 1992, 1998, 1999; Del Tredici et al. 1992).

The fifth and final type of adventitious root—and the focus of the remainder of this article—are those that emerge from the woundwood that trees produce when their trunk is damaged and its xylem exposed. In response to this damage, trees generate undifferentiated callus tissue that gives rise to a new layer of vascular cambium that produces the woundwood that will eventually cover over the injury (Stobbe et al. 2002).

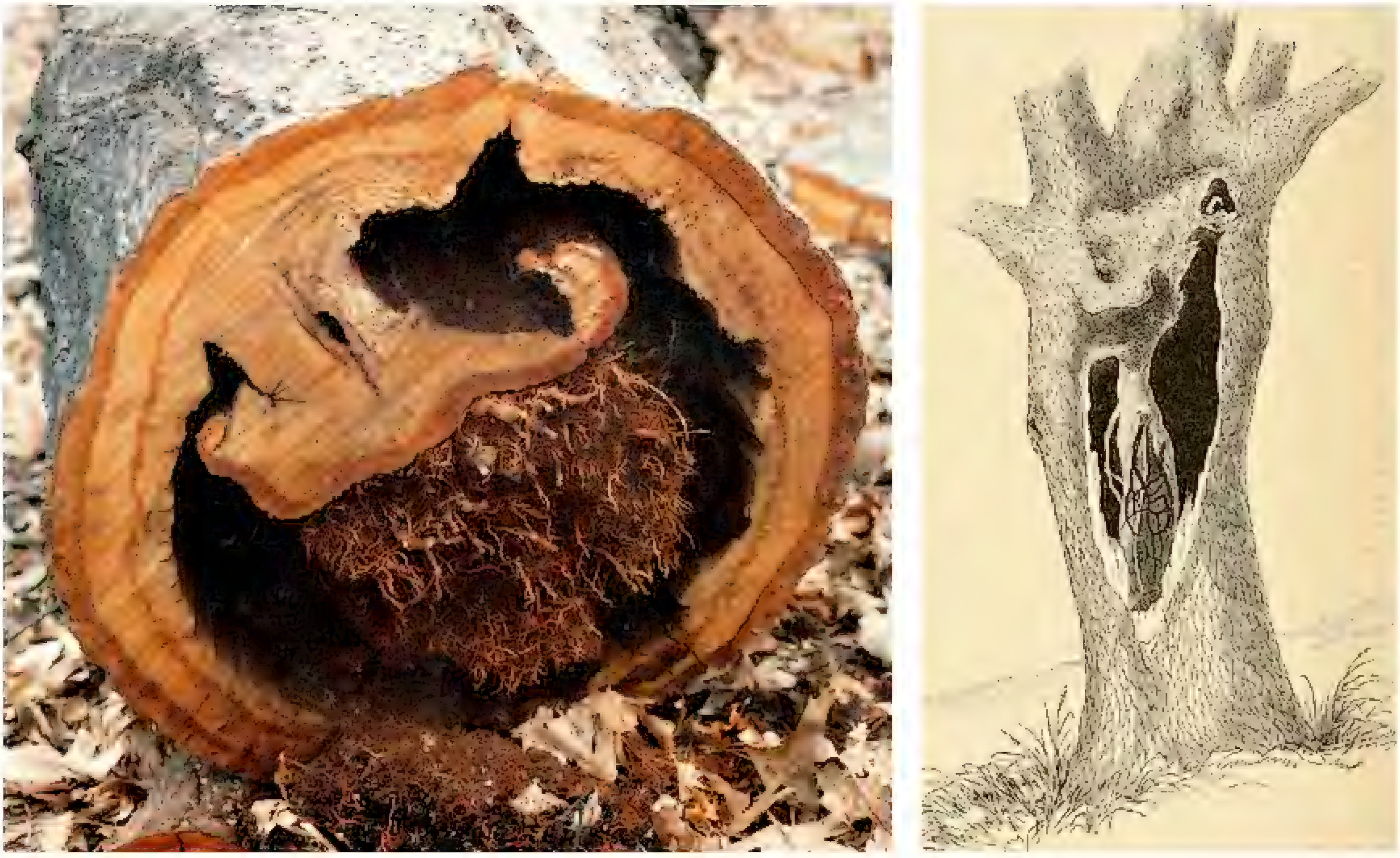
During the healing process, woundwood typically grows inward from the edges of the damage and continues growing until its margins come together to seal off the exposed wood. If the wood to the interior of this callus tissue is firm, this is usually the end of the process. If the wood is rotten, however, it offers little resistance to the expanding woundwood which rolls inward on itself and continues growing inside the trunk. In response to the moist, dark conditions within the trunk, the vascular cambium of the woundwood can initiate adventitious roots that grow into its own rotten core. If the rot extends through the trunk down to the ground, these roots have the capacity to generate a new subterranean root system and develop into stout columns that can provide extra support for the hollow trunk. While many angiosperm trees have been reported to form internal trunk roots, it is a relatively uncommon phenomenon that occurs mainly in old, open-grown specimens that have experienced extensive branch loss.

Internal Trunk Roots in the Literature

Descriptions of internal trunk roots are rare in the botanical and horticultural literature. The earliest mentions of the phenomenon that I could locate were published in the British periodical *Gardeners' Chronicle and Agricultural Gazette* between 1853 and 1877. William Booth wrote the first article and reported finding them inside the trunks of sweet chestnut (*Castania sativa*) and Cornish elm (*Ulmus minor* 'Stricta'). In both cases, the roots originated from woundwood and reached down to the ground. A second article, authored by "Vigilax," appeared a week later and described the same phenomenon in a specimen of *Laburnum*. The third reference to internal trunk roots is by Moggridge in 1870, who described four old pollarded pedunculate oaks (*Quercus robur*) growing in Richmond Park in Surrey, England, that had produced large internal, adventitious roots, two of which he illustrated. The final *Gardeners' Chronicle* article on the subject is from 1877 by W. G. S., who described a large internal trunk root in an ancient specimen of yew (*Taxus baccata*).

In the modern scientific literature, the first reference to internal trunk roots is from 1908 by O. M. Ball, who reported their existence in an old specimen of the umbrella chinaberry, *Melia azedarach* 'Umbraculifera'. He called the process "self-eating" and described how "roots descend through the decaying materials and often, upon reaching the harder, less decayed wood of the lower part of the stump, turn sharply back and grow upward even to the point of origin." He published a photograph of the specimen that shows the roots originating from woundwood.

Such was the extent of the literature until 1954, when Czech botanist Jen Jenik published a short article describing internal trunk roots in European beech, *Fagus sylvatica*. In 1975, another Czech scientist, Jarmila Kubiková, published an article that not only described their morphology in detail but also the amazing ecosystem inside the trunks of rotten linden

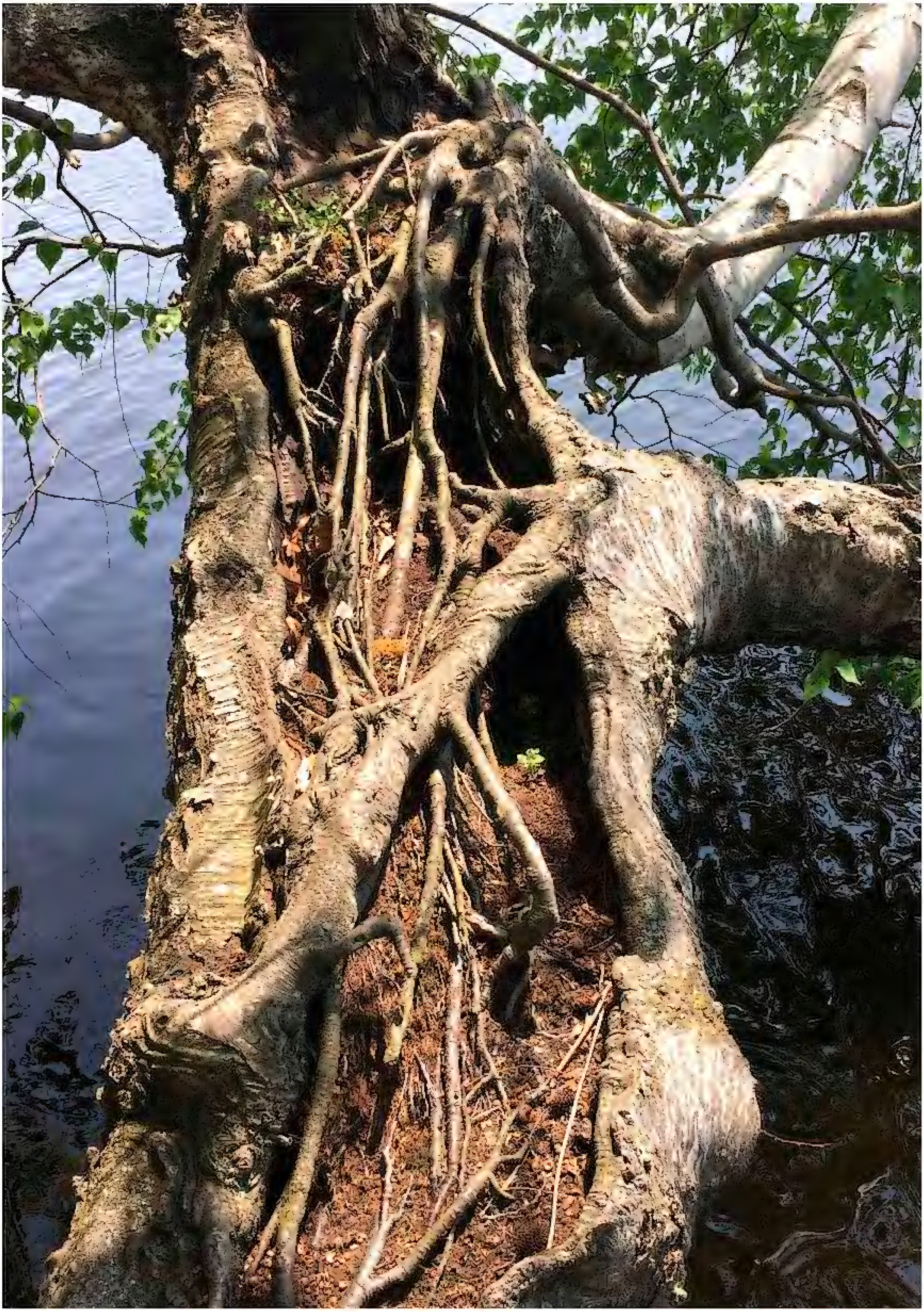


Left: An old specimen of red oak, *Quercus rubra,* at the Arnold Arboretum produced this cluster of endocormic roots from woundwood. Right: An illustration of endocormic roots in pedunculate oak, *Quercus robur,* from Moggridge's article in the September 17, 1870 issue of *Gardeners' Chronicle.*

trees (*Tilia*). To this day, Kubiková's summary of his research remains the one of the best descriptions of internal trunk roots. Noting that the phenomenon is "little known," he describes the "specific ecosystem" found within old trees, which includes "saprophytic fungi and bacteria, together with numerous protozoa, snails and various groups of insects." Internal roots only develop when the living material of the cavity "reaches the living peripheral tissues of the trunk whose meristems form the healing callus" from which root primordia eventually develop. Kubiková described their significance in older trees as "important regeneration phenomena which extend the number of absorption rootlets, improve the transport of water and nutrients, and thus enable the growth of new branches and photosynthetic apparatus. At the same time, these roots function as supplementary armature increasing the resistance of a tree to damage by wind and snow. Thus the ageing process can be retarded and the life span of the tree prolonged."

Three years later, in 1978, Dickenson and Tanner reported the occurrence of roots inside the hollow trunks of several species of Jamaican trees that were cut down in an experimental logging operation. Ten of the thirty-nine cut trees were hollow and "many" of them contained roots. They examined four trees in detail and found that in only one case the roots were produced by the tree itself. In the other three individuals, the internal trunk roots were produced by epiphytes attached to the branches of the tree or by nearby fig trees (*Ficus* sp.) whose roots grew a meter and a half upwards into the rotten trunk from the mineral soil below. The authors concluded that they had found "examples of a possible advantage gained from having a hollow trunk and examples of a possible disadvantage." Their observations are important because they remind us that the nutrients inside a tree's rotten core are fair game for any plant than can reach them from above or below.

Remarkably, it was not until 1992 that internal trunk roots were given a proper scientific name by two Chinese scientists, Liu Qijing and Wang Zhan. Working on the windswept slopes of Changbai Mountain in northeast China—which I visited in 1997—they described their occurrence in numerous old specimens of *Betula ermanii* and called them "endocaulous roots" in the English abstract of their article (which was written in Chinese). The study site was between 1700 and 2000 meters elevation with abundant annual precipitation (967–1400 mm) and



A leaning specimen of gray birch, *Betula populifolia,* along the Charles River in Cambridge, MA, producing endocormic roots not unlike those described in *Betula ermanii* by Liu and Wang.

The nutrients inside a tree's rotten core are fair game for any plant that can reach them from above or below.

fog. Because of strong winds and heavy snow, many of the birch trees were growing diagonally rather than vertically as they did at lower elevations.

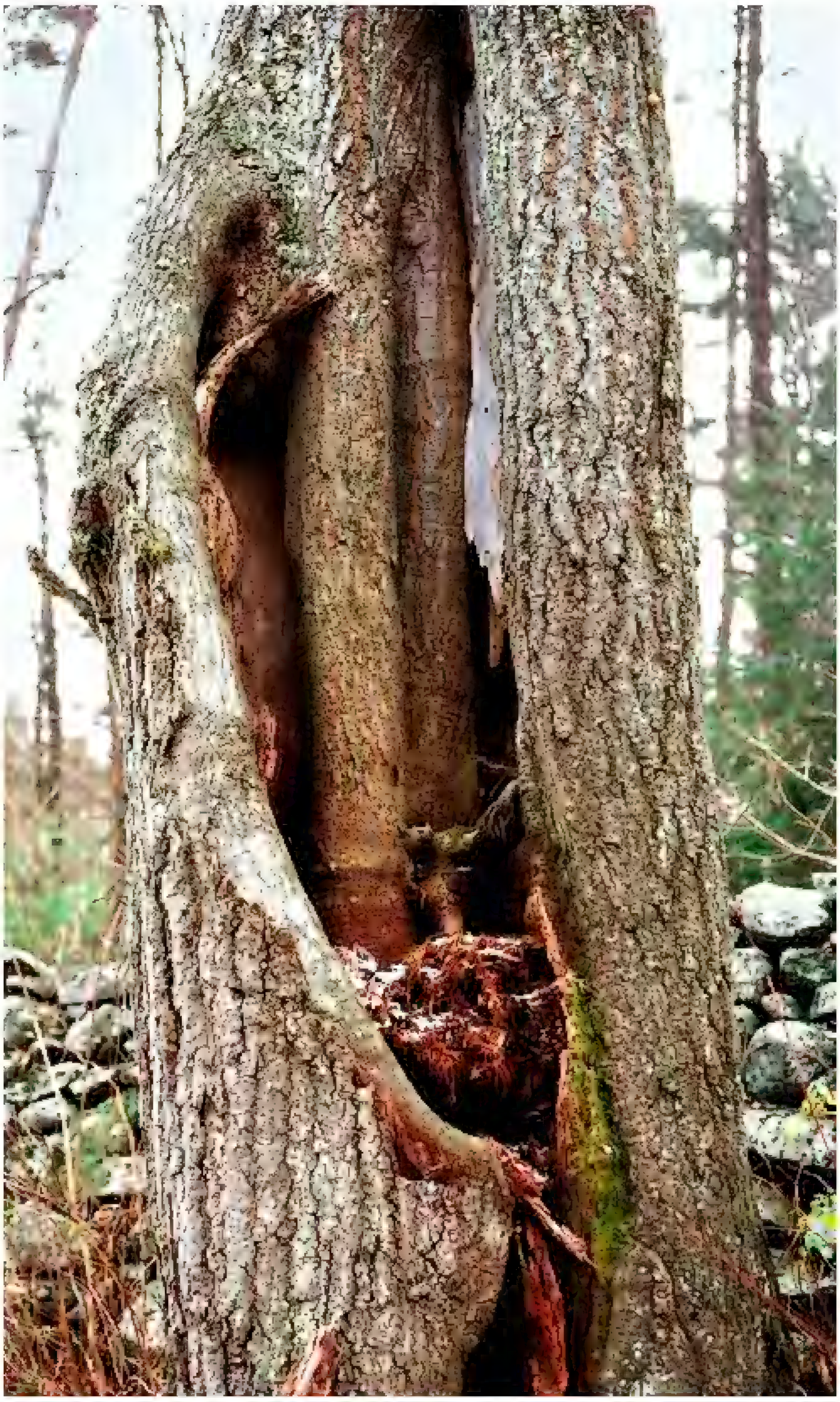
The authors looked at a large number of specimens and determined that endocaulous roots were common in trees around two hundred years old and 20 cm DBH (diameter at breast height, 4.3 feet above ground), and that these roots were able to grow down into the soil because their trunks had been hollowed out by extensive heart-rot. In younger trees, those less than 10 cm DBH, endocaulous roots were not common, and rarely reached the soil as there was much less heart-rot than in larger trees. In the moist forests on the north side of the mountain, trees greater than three hundred years old commonly developed endocaulous roots that reached the soil—up to five or more per trunk—some of which were more than 15 cm across and over one hundred years old.

The extreme weather on Changbai Mountain caused serious damage to the trunks and branches of older trees which, in turn, promoted the development of heart-rot on the inside and woundwood on the outside. When the woundwood came into contact with the soft, moist heart-rot, it generated adventitious roots that grew into it and eventually made their way down into the soil. Liu and Wang made the additional observation that, "Such rotten trees will be blown down or broken during wind storms so that endocaulous roots become visible. However, these broken trees will not likely die. Rather, their vigor increases because of the rapid development of endocaulous roots following the disturbance".

Unaware of the work of Liu and Wang, Jenik proposed calling the internal trunk roots, "endocormic roots" in 1994 based on the work of Kubiková from 1975 as well as his own earlier research from 1954. Remarkably, literature and internet searches of both terms show that neither of them have had a significant impact on the botanical or horticultural literature, a situation I intend to remedy with this article.

The prefix caul- comes from the Latin *caulis* meaning stem or stalk, and corm- from the Greek *kormos* meaning tree trunk. While both terms are appropriate, I prefer endocormic for three reasons: 1) it was proposed by Jenik, who published an early description of the phenomenon in 1954; 2) it is derived from the same root as the widely used term, *epicormic shoots,* which describes new branches that sprout from an old trunk; and 3) it suggests the use of a new term, *epicormic roots,* to describe those that are produced by the trunk or branches of a tree when they come in contact with the soil.

These roots produce tension wood that causes them to contract and thicken and, over time, provide an added measure of support for the hollow trunk.



Above: Endocormic roots have developed into columns that support the hollow trunk of this specimen of red oak, *Quercus rubra,* in West Cornwall, CT.

Opposite: An old specimen of sugar maple, *Acer saccharum,* with its humus-filled trunk permeated with endocormic roots.

The boundary between life and death is often blurred.

Observations on Endocormic Roots

I observed my first endocormic roots in 1986, in a storm-damaged red oak, *Quercus rubra,* at the Arnold Arboretum that was being cut up for removal. Midway through the process, a member of the grounds crew noticed an unusual structure inside the trunk and called me over to look at it. What I saw amazed me—the woundwood that had initially covered an old branch scar had turned inward and continued growing inside the trunk where it formed a large mushroom-shaped structure that had proliferated adventitious roots.

I have been on the lookout for endocormic roots ever since, and have observed them in various gardens and parks in a number of old trees growing as isolated specimens of various types, including: *Acer platanoides, Cladrastis kentuckea, Cornus controversa, Fagus sylvatica, Ginkgo biloba, Gymnocladus dioicus, Liriodendron tulipifera, Malus* sp., *Morus alba, Prunus* × *yedoensis, Tilia americana,* and *Tilia* × *vulgaris*. Several authors have published illustrations of endocormic roots, including Oldeman (1990) in *Fagus grandifolia;* Mattheck (1991) in *Fagus sylvatica;* Thomas (2000) in *Ulmus* × *hollandica;* Fay (2002) in *Carpinus betulus,* and Bragg (2018) in *Acer rubrum*. Writing in *Arnoldia* in 2012, Tony Aiello described an unusual specimen of *Prunus subhirtella* 'Pendula' at the Morris Arboretum in Philadelphia, in which a large endocormic root morphed into the stem of a stand-alone tree. Taken together, these reports indicate that the woundwood of most angiosperm trees has the capacity to generate endocormic roots when it comes into contact with rotten heartwood. For some unknown reason, internal trunk roots seem to be less common among gymnosperms.

In New England, I have observed endocormic roots on several species of wild-growing trees, including sugar maple (*Acer saccharum*), red oak (*Quercus rubra*), and gray birch (*Betula populifolia*). Mostly the roots were confined to the cavities filled with rotten heartwood, but in a few cases the roots extended all the way down into the ground and developed into thick columns that helped support the hollow trunk. It seems likely that upon reaching the soil, these roots produce tension wood that causes them to contract and thicken and, over time, provide an added measure of structural support for the hollow trunk. Assuming this is the case, these column roots are probably behaving similarly to the aerial roots of *Ficus* that produce reaction wood that contracts when they reach the ground (Gill & Tomlinson, 1975).

On August 4, 2020, I had the rare opportunity to observe multiple cases of endocormic root formation after tropical storm *Isaias* passed near the town of Cornwall, Connecticut where I was spending the summer, and seriously damaged many of the trees growing along the roadways. While *Isaias* caused lots of problems for the people who lived there—power was out for ten days—it offered the opportunity to observe the condition of the trees that brought the power lines down, including several old specimens of sugar maple that had been planted over a century ago for syrup production. Most of these open-grown sugar maples that lined many of the roads possessed whorls of large, upright lateral branches about three meters up on their trunks, which showed an increasing tendency to brake off in storms as they got bigger. To my surprise, many of the large laterals that broke off the old sugar maples during *Isaias* revealed "humus" inside the trunks that was permeated with endocormic roots that had originated from woundwood produced in response to earlier limb loss.

My observations on the morphology of open-grown sugar maples echoed the findings of Ranius and his colleagues who described hollow formation in the trunks of pedunculate oak (*Quercus robur*) growing in southwest Sweden in 2009. The authors found that among trees less than one hundred years old, fewer than one percent contained hollows, while fifty percent of trees between two and three hundred years old had hollows. They also observed that hollows formed at an earlier age in faster growing trees located in open pastures than in slower growing trees located in forests. The authors attributed this to the fact that most hollows were generated when large branches broke off and that such large branches formed sooner on open-grown trees than on forest-grown trees of the same age.

Management of Ancient Trees

There are long-standing questions in both the ecological and horticultural literature as to why so many trees have hollow cores and whether it compromises their stability. In 1976, Daniel Janzen was far ahead of his time in proposing that "the rotten hollow core is often an adaptive trait, selected for as a mechanism of nitrogen and mineral trapping. A rotten core is a site of animal nests, animal defecation, and microbial metabolism that should result in a steady fertilization of the soil under the base of the tree." Graeme Ruxton in 2014 proposed an economic rather than a nutritional answer to the question, asserting "the central wood of trees is allowed to decay because the costs of chemically defending it are not justified by the small reduction in structural stability that is likely to occur." To support his theory, he cited arboricultural research showing that if the radius of the inner hollow region of the trunk is less than seventy percent of the total radius, there is little cost to the tree in terms of reduced structural stability (Mattheck, 1994; Fink, 2009).

Over the past twenty years, a considerable body of research has developed on the horticultural management of ancient and veteran trees. In particular, there is an extensive literature focusing on pruning techniques that promote the long-term survival of such trees while simultaneously creating habitat for the hollow-inhabiting (saproxylic) organisms that are dependent on them (Fay, 2002, Read et al., 2010, Gough et al., 2014, Fay & de Berker, 2016, Hirons & Thomas 2018, Bengtsson et al., 2021).

One particularly interesting study by Pavel Sebek and his colleagues from 2013 looked at the incidence of hollows in pollard versus non-pollard white willow, *Salix alba,* in the Czech Republic. The authors sampled 1,126 trees across in four different areas and observed hollows in 83% of the pollarded trees and only 34% of the unpollarded trees. For trees of 50 cm DBH, they found that "the probability of hollow occurrence was 75% in pollards, but only 30% in non-pollards." They concluded that actively managing trees via pollarding could speed up the creation of habitats for saproxylic organisms and contribute significantly to the conservation of rare, hollow-dependent fauna. While the authors make no mention of endocormic roots, their research suggests that pollarding might well induce their development by virtue of the fact that it typically stimulates extensive woundwood formation. This modern approach to promoting the development of tree hollows for conservation purposes is a complete reversal of the once common practice of filling them with cement.

In addition to promoting the development of tree hollows, pollarding is known to increase the lifespan of many trees. As Oliver Rackham noted in 1990, "Trees whose function is not timber—pollards and coppice stools—may live much longer than timber trees. The cutting process prolongs their lives, and they go on doing their job of producing useful crops of poles despite old age or decay." Taking this into account, the repurposing of pollarding for conservation rather than production purposes is a "win-win" management strategy for both the trees and the organisms that live within their rotten hearts.

In conclusion, the formation of endocormic roots by old trees is a manifestation of the senescent phase of their growth. Writing in 2013, Howard Thomas vividly describes senescence as a state in which the boundary between life and death is often blurred, as a tree seeks "to control its own viability and integrity" while confronting the "thermodynamically unavoidable" eventuality of death. From this perspective, a tree's ability to transform rotten heartwood into living tissue is an incredible example of how trees can navigate the ambiguity of their mortality by generating adventitious roots.

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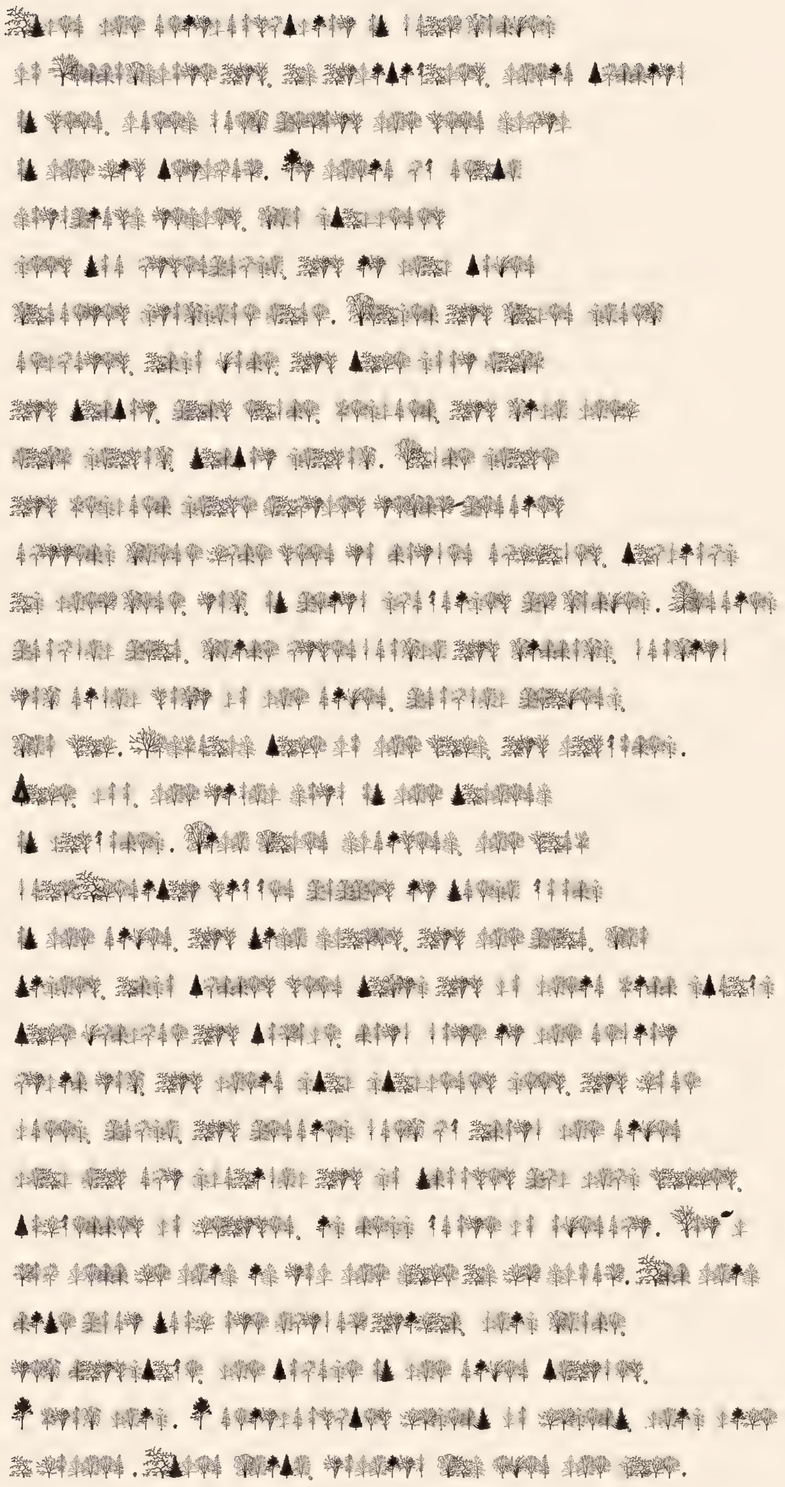
Trophic Cascade

By Camille T. Dungy, with Katie Holten

After the reintroduction of gray wolves
to Yellowstone and, as anticipated, their culling
of deer, trees grew beyond the deer stunt
of the mid century. In their up reach
songbirds nested, who scattered
seed for underbrush, and in that cover
warrened snowshoe hare. Weasel and water shrew
returned, also vole, and came soon hawk
and falcon, bald eagle, kestrel, and with them
hawk shadow, falcon shadow. Eagle shade
and kestrel shade haunted newly-berried
runnels where mule deer no longer rummaged, cautious
as they were, now, of being surprised by wolves. Berries
brought bear, while undergrowth and willows, growing
now right down to the river, brought beavers,
who dam. Muskrats came to the dams, and tadpoles.
Came, too, the night song of the fathers
of tadpoles. With water striders, the dark
gray American dipper bobbed in fresh pools
of the river, and fish stayed, and the bear, who
fished, also culled deer fawns and to their kill scraps
came vulture and coyote, long gone in the region
until now, and their scat scattered seed, and more
trees, brush, and berries grew up along the river
that had run straight and so flooded but thus dammed,
compelled to meander, is less prone to overrun. Don't
you tell me this is not the same as my story. All this
life born from one hungry animal, this whole,
new landscape, the course of the river changed,
I know this. I reintroduced myself to myself, this time
a mother. After which, nothing was ever the same.



CAMILLE T. DUNGY *is the author of the essay collection* Guidebook to Relative Strangers: Journeys into Race, Motherhood, and History, *and four collections of poetry, most recently* Trophic Cascade. *She has edited three anthologies, including* Black Nature: Four Centuries of African American Nature Poetry. *Her honors include the 2021 Academy of American Poets Fellowship, a Guggenheim Fellowship, an American Book Award, and fellowships from the NEA. She is a University Distinguished Professor at Colorado State University.*

KATIE HOLTEN *is an artist and activist. In 2003, she represented Ireland at the Venice Biennale. Exhibiting internationally, she is the recipient of numerous grants and fellowships, including a Fulbright and a MacDowell Fellowship. In her book* The Language of Trees *(Tin House, April 2023), Holten uses a "tree alphabet" of her own design to interpret the work of more than fifty contributors, including Dungy's "Trophic Cascade."*

PLANT HISTORY

Catawba: Back to the Future of the American Wine Industry

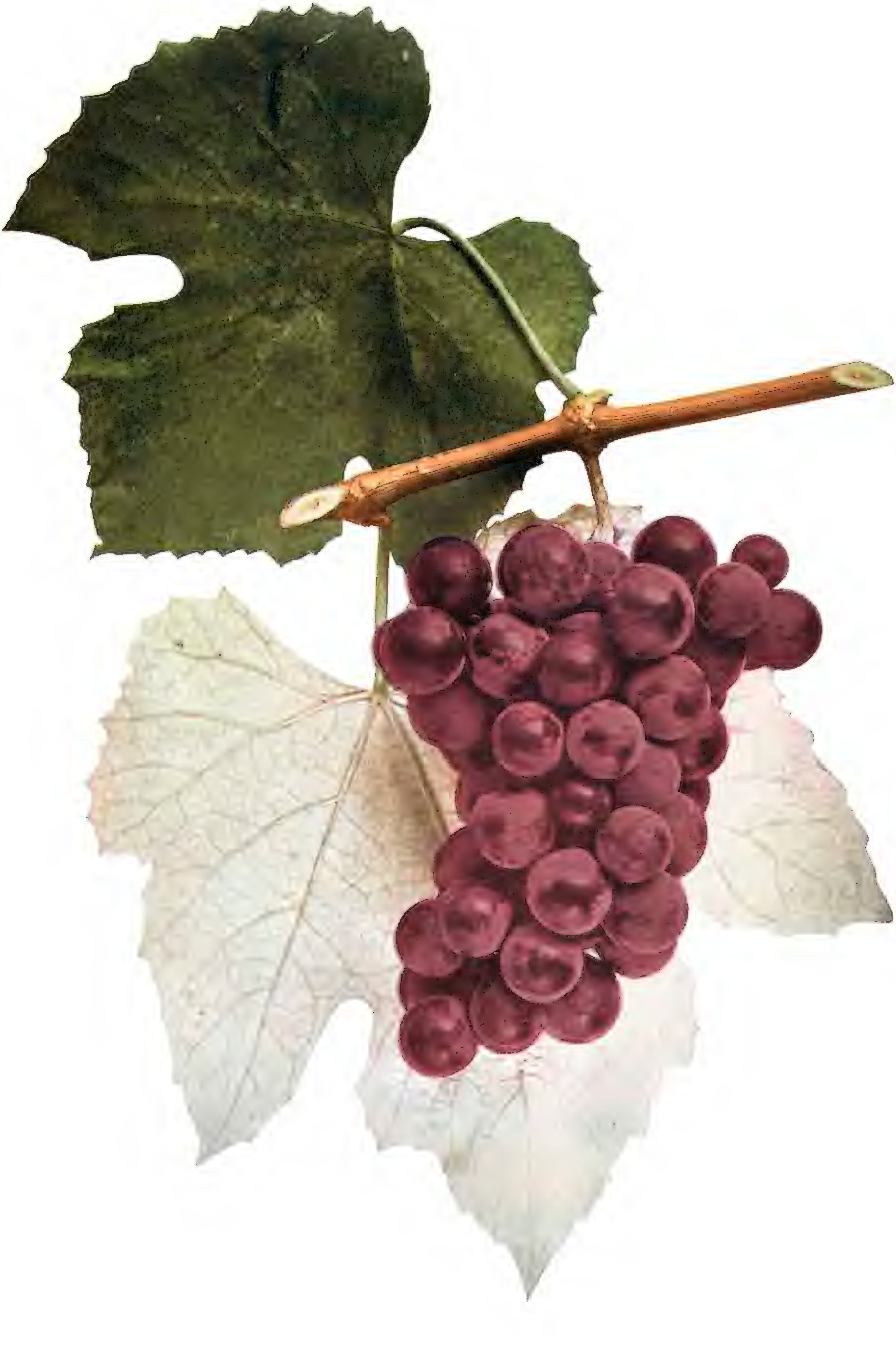
By Julia Fine

In the mid-nineteenth century, American wine drinkers found themselves obsessed with a particular grape, known for its fragrant, somewhat musky profile: 'Catawba', a spontaneously occurring cross between the wine grape *Vitis vinifera* traditionally cultivated in Europe and the *Vitis labrusca* grape indigenous to North America's eastern seaboard. By the 1850s, this hybrid had achieved vaunted status in the American wine industry. This was also the time when Ohio was the largest wine-producing state in the country, and approximately 19 out of every 20 vines cultivated there were 'Catawba' grapes.[1] Illustrated catalogs of grapes often did not include this "pionee[r] of American grapes" as it was "too generally known to require portrait or illustration by engraving."[2] Even famed poets wrote odes to the grape; Henry Longfellow waxed that this cultivar "has a taste more divine, / more dulcet, delicious and dream" than any other, so much so that it "has need of no sign, / No tavern-bush to proclaim it" as it was so eminently popular.[3]

'Catawba'—which American winemakers often argued distinguished their wine from European classics—was thus the pièce de résistance of the early American wine industry. It may seem surprising, then, that this grape fell almost entirely out of favor in the post-Prohibition era, surpassed by classic *V. vinifera* grapes. Today, few Americans have heard of 'Catawba'. Those who have may associate it with saccharine pink fortified and unfortified wines and grape juices. Across the United States, many sommeliers who are familiar with 'Catawba' decry it as "foxy," "musky," or "unidimensional," and eschew wines made with it.[4]

Why was a widely popular grape relegated to the realm of the outmoded, even unknown? Through seed catalogues, regional publications, and viticulturists' correspondence, we can trace the rise and fall of 'Catawba' and the Ohio wine industry which is often ignored in contemporary scholarship in favor of the later emergence of the California wine industry. But, as environmental historian Richard White reminds us, "in paths forged and blocked, abandoned and resumed, history shows that things need not be the way they are."[5] Once shunned by the American palate, the 'Catawba' has the potential to contribute to the reinvigoration of the American wine industry in the face of the climate crisis.

'Catawba', in Hedrick et al., *The Grapes of New York* (1908). *Image courtesy of Harvard Library*



Grape Basket Label, Lake Keuka Catawba. Undated (after 1866). *Division of Work and Industry, National Museum of American History, Smithsonian Institution*

Towards a Botanical History of 'Catawba'

First, though, what exactly is 'Catawba'? The history of the grape, much like its parentage, is murky. There are many stories regarding how settler winemakers came across the grape in the nascent United States. Some historians (perhaps apocryphally) suggest that one "General Davy" living on the Catawba River brought the cultivar to Washington DC and distributed it among friends in that area, associating the cultivar with the river (which was itself named after the Catawba or Iswa Indigenous people).[6] While the veracity of this story is unclear, we know that by 1823, 'Catawba' became more widespread, helmed by the "Father of American Viticulture" Major John Adlum who promoted indigenous grape varietals and attempted to create viticultural experiment stations. In an 1829 letter reprinted in the *New England Farmer, and Horticultural Register,* Adlum reported how he discovered a 'Catawba' vine in "Mrs. Schell's garden," in Montgomery County, Maryland. While Mrs. Schell apparently had no information as to how the family acquired this vine, she informed Adlum that her husband had referred to it as the Catawba grape.[7] Adlum, for his part, sent cuttings of the plant around the country, including to Ohio viticulturist Nicholas Longworth, who, as we will see, played a critical role in popularizing the cultivar.

From its beginnings, viticulturists have argued over the exact botanical definition of 'Catawba', with some claiming it was entirely a variety of *Vitis labrusca,* some contending it was *V. labrusca* mixed with another indigenous American grape species, and others still arguing that it was a mix between *V. labrusca* and *V. vinifera.*[8] Today, it seems as if the last hypothesis is correct, as most present-day viticulturists believe 'Catawba' is a spontaneously occurring hybrid between *labrusca* and *vinifera* that emerged after European settlers brought cuttings of *V. vinifera* to North America.[9] In particular, Catawba is probably a hybrid between *V. abrusca* grapes and "Sémillon," a white *V. vinifera* grape commonly grown in the southern winemaking regions of France.[10] As with other *V. labrusca* hybrids, winemakers prized 'Catawba' grapes for their versatility and hardiness.[11] However, unlike many *V. labrusca* hybrids, 'Catawba' has less of a "foxy" or "musky" flavor, instead often described as a "perfumey" grape.[12] The purple-lilac grapes, Adlum declared, were "the most beautiful ... to the eye, when they begin to ripen, that I know of."[13]

'Catawba' and the Ohio Wine Industry

This "most beautiful" grape soon played a critical role in the expansion of the American wine industry and westward expansion more generally. Historians have long outlined the relationship between winemaking and imperialism. Erica Hannickel, in her book *Empire of Vines,* argues that grape culture in the nineteenth-century United States was distinctly expansionist, not only in terms of artistic and literary representations of the grapevine but also the physical space the vineyard occupied.[14] As she argues, "Americans believed if they could make good wine, everything else in terroir's web"—the "totalizing ecology of the vineyard—" would be legitimated for their new country—including its land, methods, farmers, and claim to international prestige."[15] Here, Hannickel shows, "grapes and the myth of terroir rooted the nation's imperial sense of itself" during the period of westward expansionism.

One man, Nicholas Longworth, argued in favor of Ohio's potential as an ideal location for grape-growing. Inspired by both the profit and potential improvements to the nation wrought by viticulture, Longworth began growing grapes as early as 1813 in his backyard.[16] By 1823, Longworth was ready to set up a commercial endeavor. In that year, he began to cultivate his first vineyard, a four-acre plot.[17] While Longworth began planting South African Cape grapes to make madeira, he soon transitioned to growing *Vitis vinifera,* which was already popular among American consumers. He went on to dedicate himself to *V. vinifera* grapes: in one letter to the editors of the *Cincinnati Gazette,* he writes that he worked for thirty years to cultivate *V. vinifera* grapes "from all latitudes," to no success.[18]

Longworth's efforts reflect a broader preference for European wine grapes to the exclusion of wild American varieties, which stemmed from a belief in the superiority of *V. vinifera*. One nineteenth-century grape manual by viticulturist George Engelmann declared the European variety the "only true" wine grape and suggested that native American grapes were not worth cultivating due to their poor quality.[19]

However, Longworth soon found that *Vitis vinifera* was not easy to grow in the United States. In the thirty years Longworth attempted to cultivate European wine grapes, he claimed to "have never found one worthy of cultivation in open air."[20] This experience was not unique to Longworth but instead echoed throughout the nation. As one early American botanist claimed, despite the "hundreds of thousands" of European vines imported, they all failed due to the North American climate.[21] Myriad horticultural manuals from the early nineteenth century confirmed that planting *Vitis vinifera* grapes in the United States was a herculean, if not impossible, task.

From its beginnings, viticulturists have argued over the exact botanical definition of 'Catawba'.

Even after the failure of *V. vinifera* in eastern North America, Longworth remained deeply committed to growing the wine industry in Ohio. By the middle of the nineteenth century, the United States hosted several locally bred or discovered indigenous wine grapes, with genetic make-ups including *Vitis labrusca, Vitis riparia, Vitis rotundifolia, Vitis aestivalis,* and *Vitis rupestris.*[22] Longworth came to believe that these indigenous grapes would form the foundation of the American wine industry. Starting in 1823, Longworth began to focus on cultivating native rather than European grapes. An 1849 letter demonstrates his altered perspective: "We have native grapes of superior quality, both for the table and for wine.... We have neglected our native grapes."[23]

Cultivars of indigenous American grapes like *V. labrusca* were rationalized as both demonstrating the prowess of American agriculture as well as potentially transforming Ohio into the seat of wine production globally. Viticulturist William Prince argued that the existence of native species of grapes demonstrates American superiority in wine cultivation—and perhaps more generally—over Europe. He wrote in one famous treatise on the cultivation of the vine in 1830, "The vineyards of Europe are composed solely of the varieties of a single species of the vine, and that a foreign one transplanted to her soil."[24] By contrast, "in our country, numerous species and varieties are everywhere met with, springing up spontaneously in our woods and prairies, nature's own gift unaided by culture or by toil."[25] For Prince, this underscores that the United States "possess[es] not only all the advantages that France and other wine countries enjoy, from our having already introduced the choice varieties which those climes can boast, but this advantage is enhanced by the numerous varieties which our own country presents to us."[26]

Of the native grapes, *Vitis labrusca* emerged as the species of choice in Ohio for several reasons. For one, *V. labrusca* was indigenous to the American Northeast and could withstand dampness and cold—so much so that the grape allegedly failed when planted in the warmth of southern France.[27] Further, "the large size of the fruit, the vigor and productiveness of the vine, and its easy propagation from cuttings, made the varieties of this species preferable" to others, according to one 1895 illustrated catalog on the American grapevine.[28] These reasons transformed *V. labrusca* grapes into the grape of choice for early American viticulturists.

As a result of a growing understanding of its qualities, 'Catawba' grape became a popular cultivar in the Northeast and Ohio regions. One 1871 article noted the widespread preference for the grape by both "emigrants from the best wine districts of Europe, as well as those of American birth," based on "careful analytical comparison with the best foreign wines, as well as upon taste, bouquet, &c."[29] 'Catawba' was also considered by some viticulturists to have a flavor superior to most indigenous grapes. In one letter to Adlum dated February 12th, 1827, a Dr. George Holcombe lauded the recipient for his role in popularizing 'Catawba': "I congratulate you upon the success of your wines, particularly your Catawba, which is incomparably the best—much the best sweet wine I have ever tasted."[30] These reasons led viticulturists to declare that because of 'Catawba', America may someday become "the vineyard of the west."[31]

Longworth, too, recognized the immense potential of the 'Catawba' in the Ohio context after Adlum sent him a sample in 1823. Longworth soon turned his focus to the 'Catawba' grape to establish the Cincinnati wine industry as the seat of wine production in the United States during the mid-nineteenth century. He wrote of 'Catawba', "We have native grapes in most of our states, could a selection be made, which would leave us so little cause to regret that foreign grapes succeed so badly with us."[32] And he began to note the advantages of the native grape over imported varieties, claiming in one profile that, unlike certain European wines, 'Catawba' does not "run into the acetous fermentation, or become ropy."[33] The few statistics we have from the 1830s suggest that Longworth's operation was initially small. In 1833, he owned nine vineyards which produced approximately 3,000 gallons of wine.[34] By the 1840s, however, his scale of operations took off as he made a champagne-like "sparkling Catawba" which proved immensely popular throughout the nation and was immortalized in many poems. One Charles Hackay wrote an ode to the grape, ending with "Catawba! Heart warmer! / Soul cheerer! life-zest! / Catawba, the nectar / And balm of the West." In 1850, Longworth produced 60,000 bottles of Catawba wine; that number rose to 75,000 by 1852.[35] These bottles sold very quickly: one 1852 report noted that demand was "much above the ability of Mr. L. to supply."[36] Catawba had rapidly become one of the most popular—and most quintessential—American wines.

Historical Forces of Failure

But even as 'Catawba' represented a successful departure from European wine grapes, most producers continued to employ European-style viticultural techniques. The 'Catawba' grape was raised in a highly regimented, monocrop culture typical of many European vineyards.[37] Longworth also chose to use trellises to support his plants in the typical Rhineland style. Present-day viticulturists suggest a potential reason for this imitation of Rhine viticulture: whereas European vineyards in flat areas do not use trellises as the vines are able to support themselves, the younger vines of the United States could not stand alone, therefore requiring trellises like the grapes growing on the steep hills of the Rhine.[38] Another potential reason was that most of Longworth's vineyards were run by German immigrants, many of whom came from the Rhine.[39] Their experience growing grapes in Europe may have led them to adopt similar techniques upon arrival in Cincinnati, even though the topography of Ohio differed from that of their natal lands.

This attempt to transform Cincinnati into the "Rhineland of the West" ultimately failed, in part due to this adherence to traditional European styles of viticulture. Because the 'Catawba' grape vines were planted so close to one another and monocropped, they were particularly susceptible to airborne fungal diseases and pests not initially found in Europe. The most destructive of these diseases originally

Even as producers opted for indigenous grapes, they stuck to traditional European cultivation mechanisms, leading to the industry's ultimate failure.

found in America was black rot, which before the 1880s had only been observed in the Eastern United States. Black rot is a fungal disease that appears in the rainy season, as "water activates the release of fungal spores."[40] The spores cause the grapes to shrivel, making them unusable. By 1885, black rot was reported in France, most likely from the transfer of grape vines from the United States to Europe.[41] However, this particular fungal disease had not been recorded on the European continent before that time.

Because of the controlled, tight planting of the 'Catawba' grape, black rot deeply impacted the Ohio wine industry. According to a 1911 article on the wine industry in Ohio, "From 1850 to 1880 it was difficult to get a bunch of any size and evenly ripened where it escaped the rot."[42] Despite this problem, viticulturists like Longworth continued to praise 'Catawba' as the best of America's native grapes. It is unclear why Longworth remained so loyal to 'Catawba'; perhaps it was due to the popularity of sparkling 'Catawba' nationwide or fealty to the idea of producing wine from a grape native to America. By the 1860s, the tide began to turn against 'Catawba'. Viticulturist George Husmann, at a meeting of the Missouri Horticultural Society, allegedly tried to place 'Catawba' on the "rejected list" of vines, given its liability to various fungal diseases.[43] And, just five years later, in 1865, one outlet lamented, "We regret to learn that this variety of grape is nearly destroyed the present season by rot.... Every one having the Catawba in this vicinity, tell us a sad story about them in the present season."[44] Here, then, we see a paradox of the early Ohio wine industry: even as producers like Longfellow opted for indigenous grapes rather than European *vinifera,* they stuck to traditional European cultivation mechanisms, leading to the industry's ultimate failure.

Some wine producers recognized that the problems with 'Catawba' could be solved by departing from European viticultural methods. One "E.P.C," writing in a popular Cincinnati newspaper in 1858, argued that the grape was sensitive to diseases only "when not sufficiently aired and ventilated." The author underlines the failure of traditional planting techniques: "That our old mode of close planting, heading-down, and crowding to the earth, with a view to get branches as near the ground as possible, is not calculated to remove this difficulty, is clear to all and self-evident."[45] Anecdotal evidence suggests that he was correct: an 1888 contributor to a national agricultural journal notes that when he planted 'Catawba' with more room than normal, "there has been no rot in twenty-eight years."[46] Such alternatives demonstrate that 'Catawba''s proto-industrialized, regimented nature catalyzed the spread of black rot.

However, vineyardists in Ohio, like Longworth, continued to plant 'Catawba' in the traditional Rhine style. It is unclear why this happened when national farming magazines and local papers printed information advising against monocropping 'Catawba' grapes so close together. Further, it is clear that alternative methods of grape-growing were present in other parts of the United States. Viticulturists in the Hudson Valley, for example, often practiced "mixed-fruit farming" by planting red currants below the grapes and raspberries, strawberries, or a vegetable in between vineyard rows, with fruit trees at the end of every third row.[47] The Ohio industry could have drawn upon these alternatives. Instead, perhaps due to attachment to European agricultural traditions, the monocultural cultivation of 'Catawba' pushed the Cincinnati wine industry towards its end. By the 1860s, the wine industry in Ohio folded in part due to fungal diseases.[48] Its ravages, combined with the lack of laborers in vineyards due to the Civil War, as well as the death of Nicholas Longworth, meant that by 1870, grape-growing almost wholly vanished from Ohio.[49] The Ohio wine industry—and the 'Catawba' grape that undergirded it—folded after just 50 years. Soon after, the behemoth we know today as the California wine industry took off in Ohio's stead. Other wine regions, like the Hudson Valley, also came into vogue as the cooler climate limited fungal pressures.[50]

The Catawba Wine Renaissance?

But even as the Ohio wine industry failed, the 'Catawba' grape never totally disappeared, but is used in "Pink Cats" sweet wine as well as Kosher juice and wine.[51] And today, Catawba wine is making a comeback. Skeleton Root, a popular Cincinnati winery, is "focused on the revitalization of the local growing region," and makes delicious and unique Catawba wines that pay homage to Longworth's legacy.[52] As Skeleton Root winemaker Kate MacDonald noted, "The West Coast is very forward about wine heritage, particularly in Sonoma where they have a lot of pre-prohibition wineries.... I became obsessed once I learned about Cincinnati's wine heritage." For MacDonald, using grapes like 'Catawba' is an opportunity "to produce a wine that's uniquely American and uniquely Cincinnati."[53]

As MacDonald points out later in the interview, 'Catawba' offers more than a fascinating window into American agricultural and environmental history: it also offers a potential path forward in light of climate change. As the climate gets increasingly hotter and more unstable, fungal disease, which thrives on moisture, has the potential to impact grapes even more than normal. "Instead of spraying [fungicides] like five times a year, which we would have done 15 or 20 years ago, we are having to spray 12 or 15 times a year," explains viticulturist and historian Stephen Casscles.[54] "I'm the one spraying these things, [so] I just would rather not use things that are highly toxic," Casscles says. "Or, if I am, I'd rather use them three times a year rather than twelve."[55]

It is ironic that, despite the fact that 'Catawba' initially failed due to fungal disease, many winemakers are convinced that when grown in a more spaced out, polycultured manner, the grape can offer a potential antidote to frequent spraying. "The *labrusca* varieties are marvels of biology" says Phil Plummer, a winemaker at a Montezuma Winery in New York who works with 'Catawba' grapes. As he explains, *V. labrusca* grapes co-evolved with many of the fungal diseases and pests native to North America. "If you can develop a hybrid," he notes, "there are some of the characteristics and flavor and aroma of a *V. vinifera*, with some of the hardiness and disease resistance of the wild grapes that grow around here." This allows Plummer to successfully propagate grapes like 'Catawba' without "breaking the bank or being out in the vineyard with the sprayer weekly."[56] This is necessarily an important issue in environmental justice: Justine Belle Lambright, director of external business at the Kalchē Wine Cooperative in Vermont, points out, "Although the majority of workers in a vineyard are Black and brown bodies, they only make up one percent of the ownership level." Hybrid grapes, which tend to require fewer chemical inputs, thus can improve health conditions for workers of color.[57]

While many historians have marked the Ohio wine industry as simply a failure, the long history of 'Catawba' suggests the vitality of the early American wine industry and a path forward for winemakers today. Hybrid grapes like 'Catawba', alongside other hybrids including 'Croton', 'Empire State', and more, allowed the industry to thrive for many decades. While 'Catawba' may have initially failed in the American wine industry, from its failure—as well as its successes—we might find new ways forward in cultivating crops during our current climate crisis.

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VISUAL ESSAY

Olmsted Trees

By Stanley Greenberg

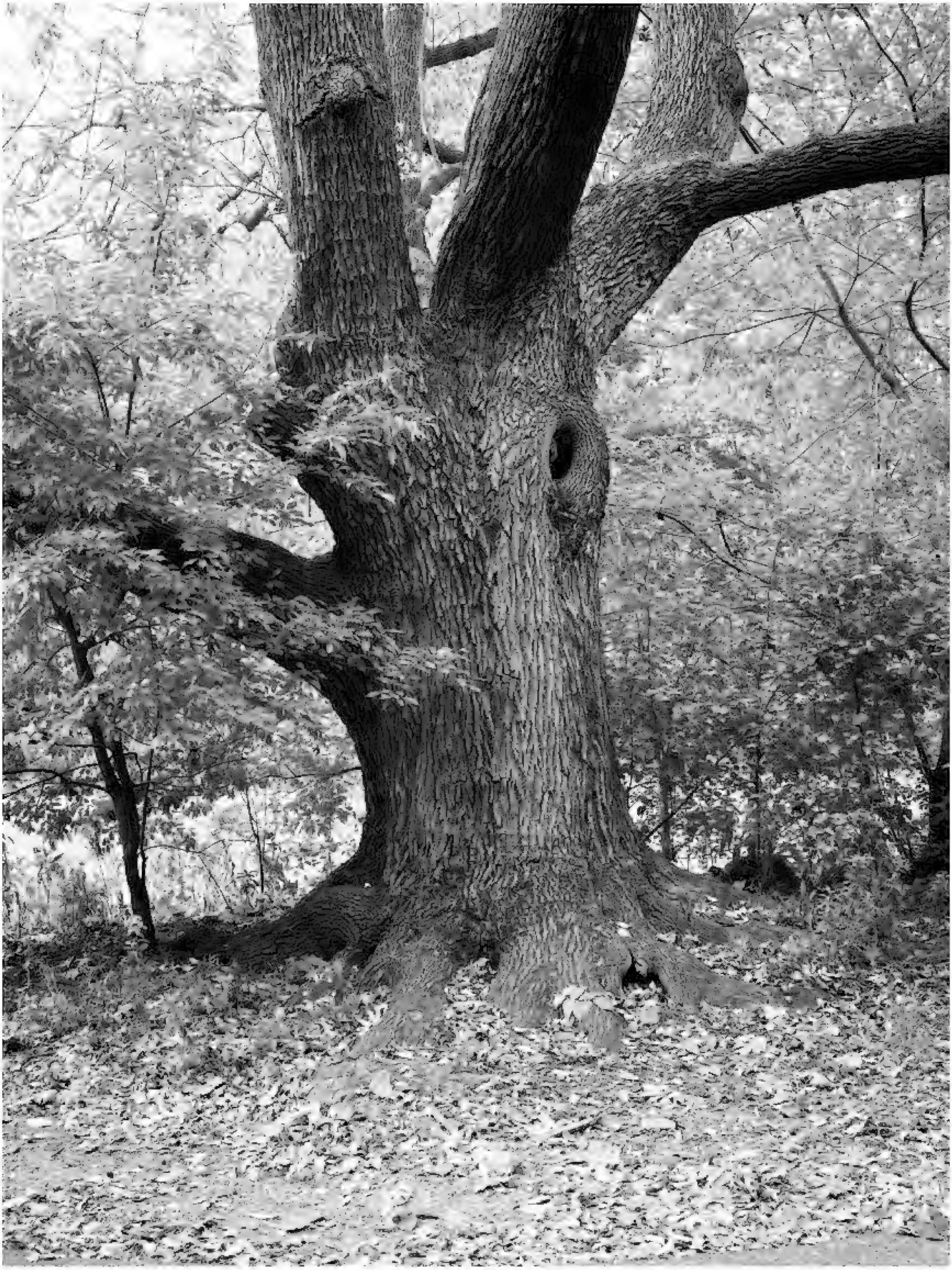
Much of Brooklyn-based photographer Stanley Greenberg's work explores infrastructure—and as a lifelong New Yorker (and onetime city parks-department employee), he knows that parks are urban infrastructure as vital as any aqueduct or reservoir. Greenberg's recent book, Olmsted Trees, *documents his hunt for trees surviving from Olmsted's time in parks from New York and Boston to Milwaukee, Wisconsin and Louisville, Kentucky. In a recent conversation, Greenberg reflected on the sometimes awe-inspiring, sometimes unsettling thoughts trees provoke about time and the nature of change. His remarks here are edited and condensed.*

I'm in Brooklyn's Prospect Park almost every day. A few years ago I learned that the Prospect Park Alliance had surveyed all the trees in the park, and I realized that I could use it to find the largest and, probably, the oldest trees. With some help from parks staff and an old guidebook, I learned that some of them dated from Olmsted's time. I spent a few days photographing in the park, and then in Olmsted's Chicago parks. Olmsted always said he was designing his parks for how they would look one hundred years from now, and I wondered what the hundred-year-old trees looked like. And that made we wonder if we're thinking enough about one hundred years from our own time. I also realized that Olmsted's two hundredth birthday was coming soon. I decided to try to visit every Olmsted park where he had selected all the plantings. The pandemic slowed my work, but most parks were relatively easy to get to from New York. After many rejections I found a publisher, and my editor wanted a timeline of all the parks in the book, and when the trees were planted. In many parks there were some records, or historical surveys had been done, or arborists showed me their best candidates. I also made educated guesses based on old guidebooks and relative tree sizes. The Arboretum was the only place that had detailed planting records. But as for the timeline, it was almost impossible—because, when is a park finished? Even as far as Olmsted was concerned, he'd work for a few years, and there were probably ten or twenty years of planting to do. So, who's to say when a park is "done"?

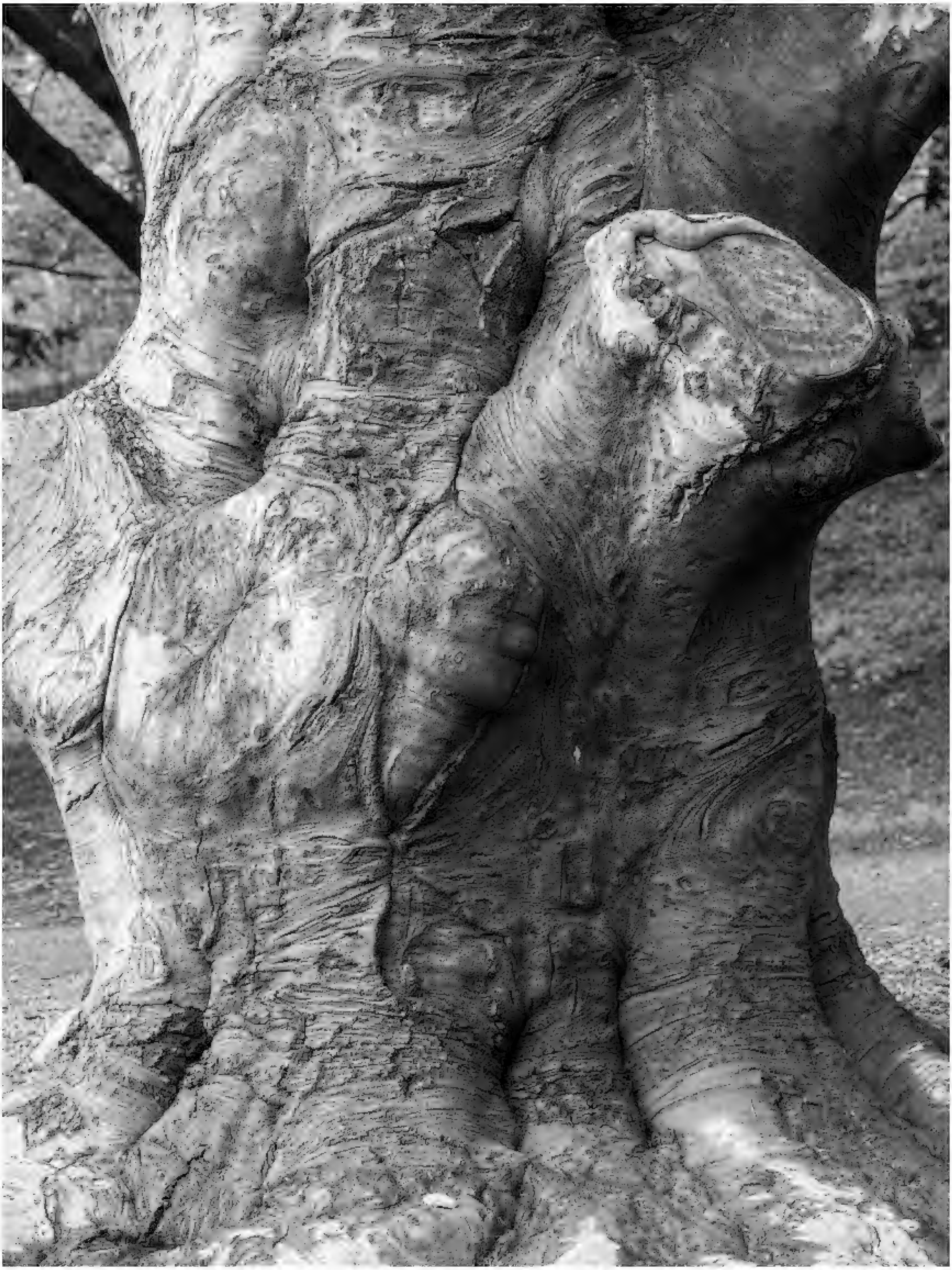
This is the first project I've done that's been just about "nature." Much of New York's water supply, which I've photographed extensively, is in somewhat-altered nature. And Olmsted's parks, of course, are mostly constructed (though there were places where he refused to touch what was there). I'm out in nature often, but tend not to photograph when I'm there. This project has shown me that there are things I want to photograph in that world, and has shifted my work in a new direction.

Olmsted Trees
By Stanley Greenberg
With essays by
Tom Avermaete,
Kevin Baker, and Mindy
Thompson Fullilove
160 pages | 120 color
plates | 9 x 11
Hirmer Press, 2022

Opposite: *Platanus* x *acerifolia,* London plane. Highland Park, Rochester, New York, 2020. *Photographs by Stanley Greenberg.*

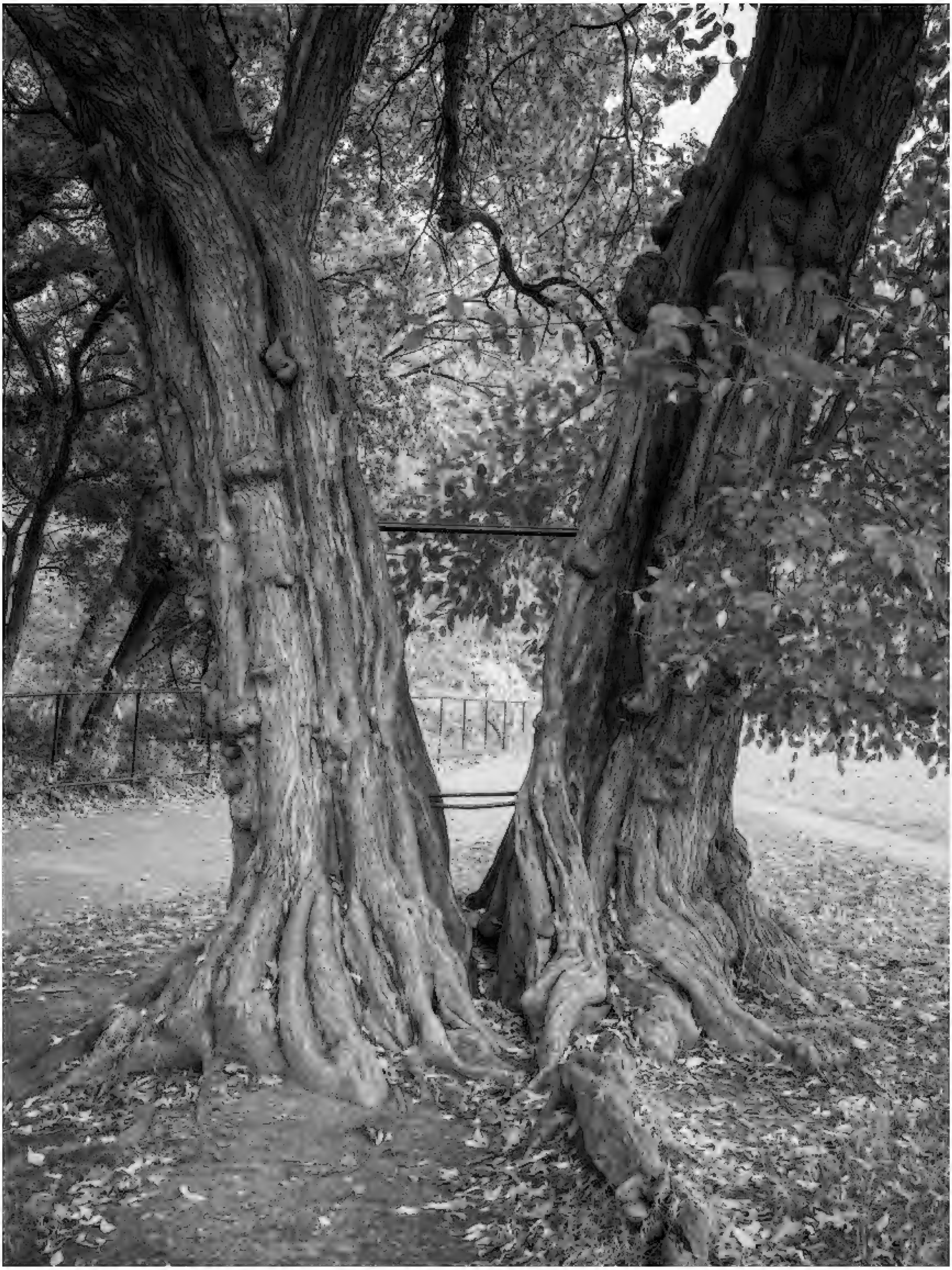


Fraxinus americana, white ash. Prospect Park, Brooklyn, NY 2021.

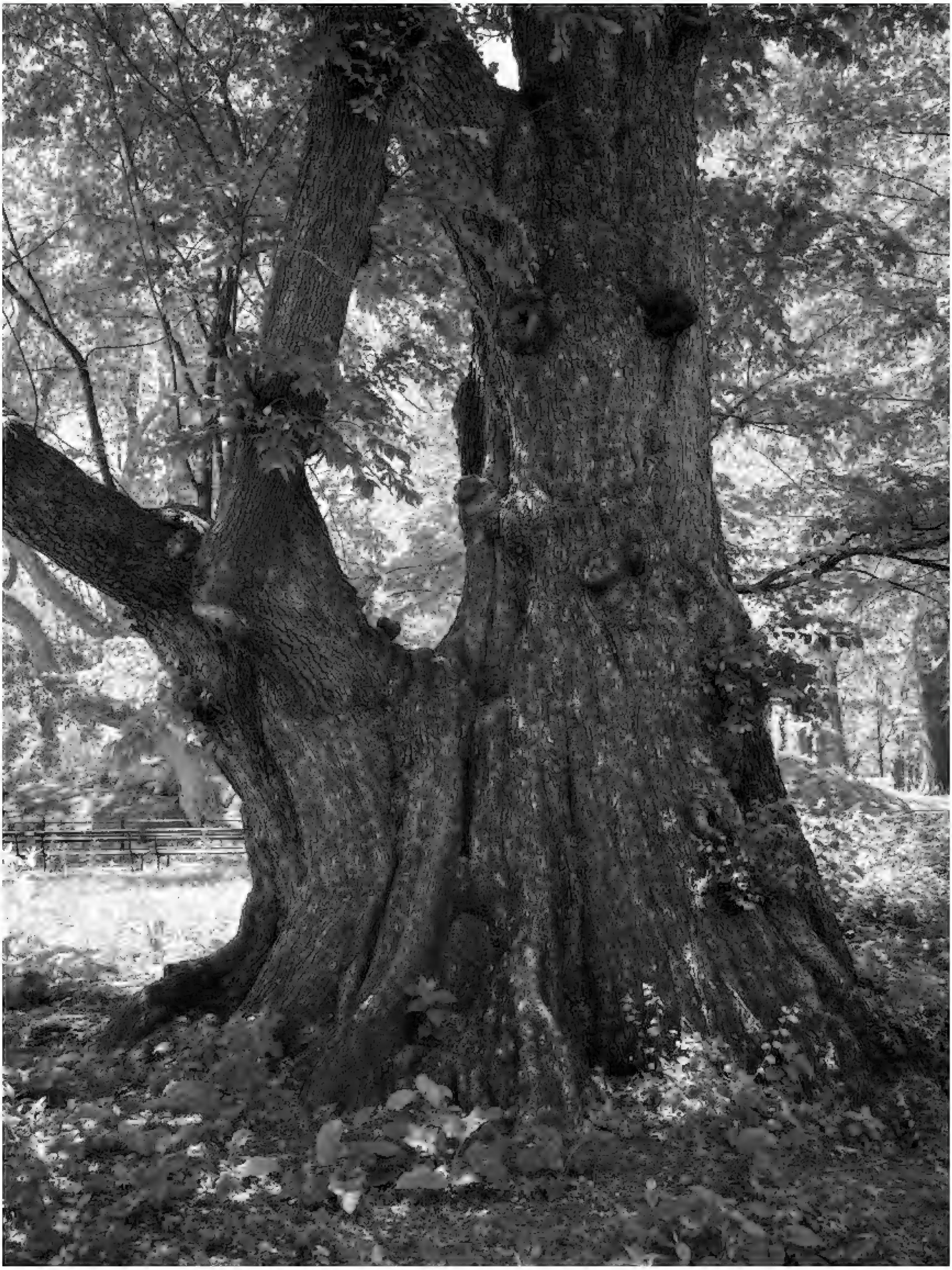


Fagus sylvatica ‘Asplenifolia’, European beech. Arnold Arboretum, Boston, Massachusetts, 2021.

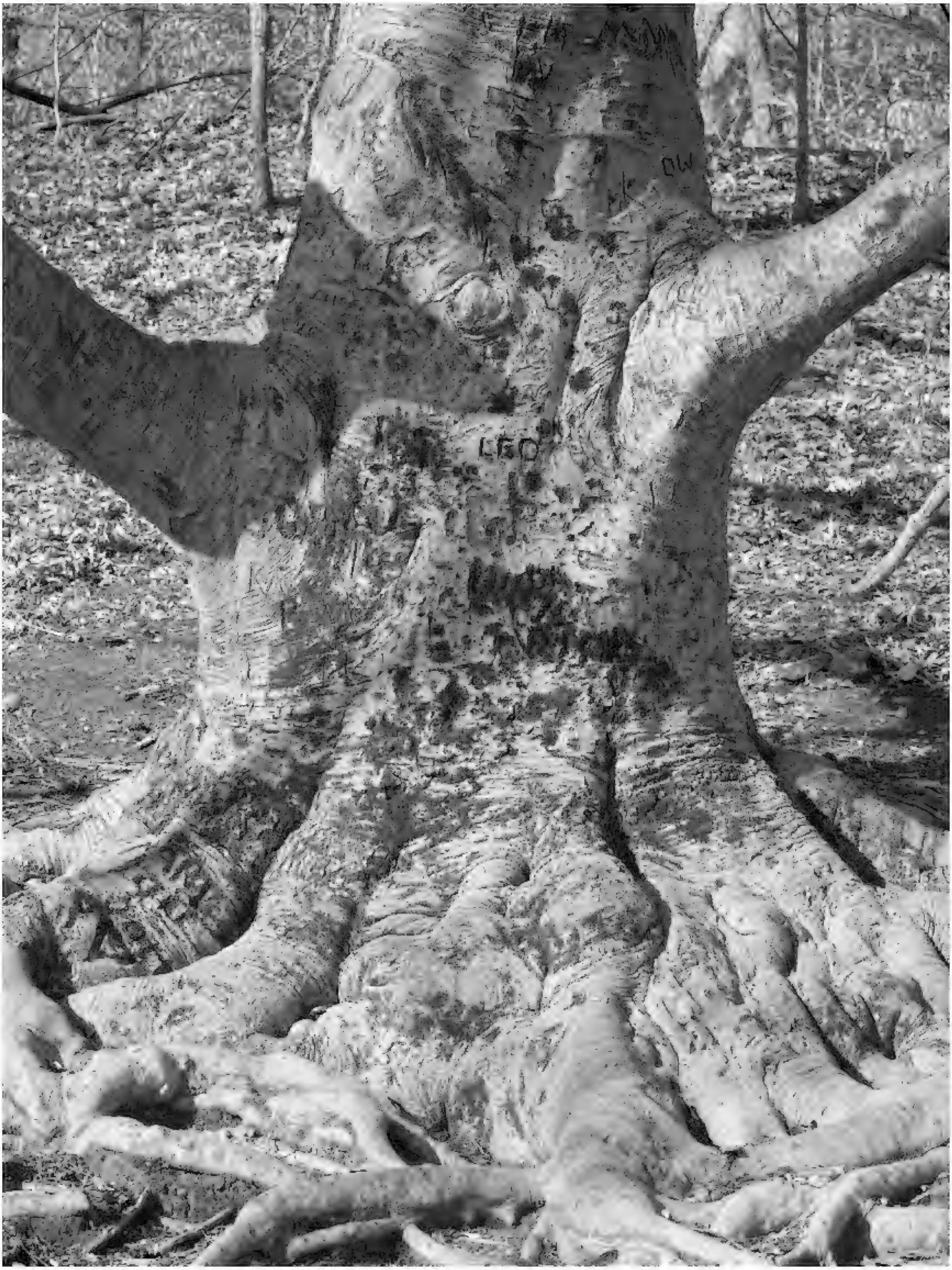
Quercus rubra, northern red oak. Downing Park, Newburgh, New York, 2020.



Maclura pomifera, Osage orange. Prospect Park, Brooklyn, New York, 2021.



Ulmus minor, English elm. Central Park, New York, New York, 2021.



Fagus sylvatica, European beech. Jamaica Pond, Boston, Massachusetts, 2020.

STANLEY GREENBERG *is a photographer based in Brooklyn. The author of eight books, he exhibits his work around the world, and is the recipient of many awards, including the Guggenheim fellowship and an NSF Antarctic residency.*

Propagations

GREEN CITIES

City Trees, City Seasons

By Kevin Walker

It is a curious fact that from any of the green public benches found throughout the city of Boston, you can see a tree. And there is no starker contrast to be found in the polarized city of Boston than between the trees of summer and the trees of winter. Throughout Boston's parks and streets, but particularly down along the granite banks of the Charles River, the dreaming trees of summer are as different from the hibernating trees of winter as sunlight is from moon light.

The bench where I sit is the bench where I sleep: a green hardwood bench along the Charles River watershed in Boston. My green bench serves double duty as a place to sit and observe the seasons, and, come bedtime, a place for this "rough sleeper" to spend his homeless nights. My bench is in the vicinity of several river trees I've grown to know—and by sleeping between the trees, I know it ain't skid row! I'm in good company with all the gallant elms, sycamores, lindens, mulberry, crabapple, and maple trees found lining the bicycle paths of the Emerald Necklace.

And I've noticed over the years camping out that each of these species has a unique reaction to the environment. It's as if a tree could have a personality. It saddens me when a favorite tree loses a large limb due to a harsh winter wind; and I wince in the summer when a large, noble, fully-leaved tree snaps and gets knocked over on top of a footbridge, necessitating its destruction in a giant woodchipper. The occasional stump of a tree looks to me like a boarded up & closed business, reminding me that an important community asset has been lost.

Branches stretching skywards towards the light with roots descending into the darkness, the tree is a sentinel of time, a living testament that cannot be recovered if the tree is destroyed by fire or simply knocked over by wind. Silent witnesses to so much Boston history, trees inspire further acts of wisdom: to plant as many trees as possible. Thus, "arborist" is a particularly sagacious vocation.

Cheerfully greening and especially beautiful, the trees of summer stretch up towards the sun like so many cathedral spires. Tall and broad like a circus tent, sacred since time immemorial, summer trees are also companionable, providing protection against a sudden rainstorm or providing shade to enjoy a picnic, and glorious, no matter how insect ridden or gnarly they may be.

Not all trees are treated equally, however. One particular tree from Asia, called The Tree of Heaven (*Ailanthus altissima*), is classified as a noxious invasive species. Thought to have been brought to the U.S. in 1784, It is found throughout Boston today. *Ailanthus altissima* is notorious for producing a chemical that retards the growth of other plants (though other trees do this, too), while its roots can damage sidewalks, sewers, and the foundations of buildings (again, this happens with many other tree species, including natives). No tree is perfect, and I can understand that they sometimes need

Illustration by Simon Prades

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to be removed. My regret is lessened when I realize that more trees are being planted around Boston on a regular basis.

The Charles River estuary is lined with trees, their shiny brass identification tags tinkling in the wind. The early evening darkness is pierced by soft moon glow, silhouetting branches against Boston's crenellated skyline, reminding me of the strange and disturbing paintings of Gustave Doré, or an old Civil War daguerreotype, a bleak scene in shades of gray.

All trees serve some purpose in the judgement of the arborists who plant them or the neighborhoods that demand them. There are approximately 125,000 trees in the entire city of Boston, and more than 35,000 of these are street trees. Healthy public trees provide much more than shade: they filter air pollution, contribute to climate control, store rainwater and reduce erosion, connect the city to various ecosystems, and provide stable habitat for beneficial insects, birds, and animals.

As I limp around the city of Boston, pushing my shopping cart ahead of me in my homeless pilgrimage, the days of tree watching go by slowly, while the years feel quick. I make my way along the footpaths of the Charles River basin, noting the work done on trees. Most of the round brass tags nailed to the trunks have blown off in the winter, while those which remain show various I.D. numbers. Newly planted saplings have plastic tags snapped around their branches, identifying them by species: Northern Red Oak, Swamp White Oak, Little Leaf Linden. I have come to know the trees by the shapes they take, the pattern of their leaves, and the shade or protection they offer. My favorite trees provide deep shade in the searing sun, dense foliage against the down-pouring rain, or wide trunks to offer protection against the sudden winds of a violent squall. Those three types of trees I consider my friends.

Kevin Walker is a lifelong Bostonian, now homeless more than twenty years, giving him "perspective on a different side of the city," he writes.

ART ENTANGLED

Grafting the Past to the Future

By Heather Kapplow

Though raised on a Pennsylvanian farm, Syracuse-based artist Sam Van Aken was unfamiliar with fruit cultivation when he started working with trees as an art medium. Van Aken's most recent artwork, *Open Orchard,* is a distributed, site-specific fruit orchard, part of which exists as a long-term art installation on public parkland on Governor's Island in New York City, and the rest of which is scattered around the boroughs of the city, echoing the planting patterns of generations of immigrants that brought plants and seeds with them to New York from their respective homelands.

The part of the orchard that is on the island is in an idyllic location, cascading down a gentle slope overlooking New York Harbor. Getting it there was a long journey, beginning in 2014. "I had been shopping around for a place where I could plant one hundred trees in New York City, and people would kind of pat me on the back and say 'good luck!'"

Van Aken's lucky break came when he was introduced to curator Shane Brennan, who had just become Director of Public Programs on Governors Island. Brennan responded to the idea immediately, but it was such a drawn-out process that Brennan moved on before *Open Orchard* was realized. Even finding the right location on the island took several years.

The final location was determined by topography. "Fruit trees like to be on raised hills," Van Aken explains, "so the cold can run off." But the location ends up also being very resonant with *Open Orchard's* theme of fruit cultivation as a portrait of the people who have migrated to and lived in New York. "I still pinch myself, because I can't believe that the orchard is there," he admits. "There's a view when you come from the back part over the hill, and you look down the road, and you see Ellis Island, and the whole project sort of comes together."

The 102 trees on the island will be matched by a roughly equal number planted around New York City, through a collaboration with NYC Parks' community gardening program, Green Thumb (some of these are already in place, others are in a nursery on Governor's Island, in various stages of grafting). Each tree will bear four or five varieties of fruit (apple or stone fruit),

Illustration by Sam Van Aken, courtesy of the Trust for Governors Island all of which are native to or have been historically cultivated in New York.

"There are over 100 varieties [of fruit] that originated in New York," explains Van Aken. Only about two dozen of these are still actively (i.e., commercially) cultivated, but Van Aken was amazed by how much detail he could find about what has grown in New York over the past three hundred years. "I tracked varieties down to intersections, street corners, and farms. And then I took that historical map of New York City, laid it on top of a current one, and realized that I could place these varieties back into the places they originated from. We're currently in the process of doing that. I think today, we've distributed about fifty trees."

"If you're ever feeling low, just give somebody a tree."

Van Aken worked with the U.S. Department of Agriculture (USDA), accessing their germplasm collection to work with varietals that have ceased to exist outside of their archive. "With a fruit tree, you can't [just] store it as a seed, right? So they keep a living sample going. For apples, they store samples in Geneva, New York. For pears, in Corvallis, Oregon. For stone fruit I go to [University of California,] Davis. They'll keep a living example in each of these locations, but then they'll also maintain it as tissue culture."

Trees matched with community gardens get paired with local caretakers, and Van Aken also offers comprehensive grafting workshops and tree-care training materials through Green Thumb as part of the long-term plan for maintaining the off-island part of the orchard. "It's been amazing, distributing trees to people. If you're ever feeling low, just give somebody a tree. I get pictures from the community gardens with five people holding a potted tree and they're just beaming and I'm like, 'I'm doing something right,' you know?"

The fruit in *Open Orchard* spans from pre-contact (pre-colonial) times until about WWII, and includes many fruit varieties that hadn't been accessible for 150–200 years. The newest fruit variety in the orchard is the Stanley plum, developed in Geneva, New York in 1938. "The oldest European variety" says Van Aken, "is the Damson plum. That's believed to date back to Damascus [11 BCE] and was brought into Europe, where it became naturalized and then brought here.... But, the beach plum, that's been in New York for 10,000 years!" In fact, it may have always been on Governor's Island. "Verrazano [1524] and Hudson [1609] both mentioned it when they sailed into New York Harbor. It's kind of crazy to think that the shoreline of New York was completely lined with these plums that would blossom in white in the spring. It's a far cry from what it [the shoreline] is now."

"When I was looking at all those [tree] placements for community gardens" Van Aken shares, "I realized I had to work with the Lenape Center on this." Van Aken cold-emailed The Lenape Center, and they enthusiastically invited him into a few of their own projects—for example, an exhibition that the group curated for the Greenpoint branch of the Brooklyn Public Library, which includes a teaching garden composed of "indigenous fruit trees" cultivated by the Lenape in Manhattan, and meant to build "continuity between ecological past and present." The Lenape Center helped Van Aken arrange for all of the native tree varieties to be planted in Prospect Park (including beach plum, American plum, black cherry, chokecherry, and American persimmon), and also has a future collaboration with Van Aken in the works.

Open Orchard grew out of Van Aken's earlier fruit-tree-related work, *Tree of 40 Fruit*, where the artist pushed the orchardist's practice of grafting to its outer limits. Bearing a title that rings equally biblical and futuristic, Van Aken's *Tree of 40 Fruit* is a living artwork, with editions spread throughout the world, each producing blossoms and then fruit of 40 different stone fruit varieties.

His motivations for constructing *Tree of 40 Fruit* were among the most traditional artistic drives: he wanted to create something impossible and unexpected—to surprise and delight people when a normal looking tree in their fall/winter environments burst into multi-colored flower in the spring and then a fruit basket in the

Heather Kapplow is an artist and writer based in Boston. For more details, see www.heatherkapplow.com.

summer. But as is often the case in art making, the process became at least as interesting a project as the outcome. In this case, the process brought up big questions about the sustainability of how fruit and knowledge about fruit gets shared.

Van Aken's efforts to realize *Tree of 40 Fruit* raised the specter of varietal extinction. There were once thousands of varieties of stone fruit in the United States, but because of fruit industrialization, it was difficult for him to find and graft scions from enough different varieties for *Tree of 40 Fruit* to live up to its name. The work thus became an odyssey of archival research and relationship building, and ultimately transformed into a preservation project: purchasers of *Tree of 40 Fruit* don't just own a unique edition of an artwork. They own an entire cultural history—a living collection of beloved fruits brought from one place to another via immigration—along with some responsibility for keeping rare varieties of peaches, plums, apricots, and cherries present in the future.

If no one "owns" the trees, who looks out for them?

When searching for fruit varieties for *Tree of 40 Fruit,* Van Aken found himself welcomed at agricultural research stations and the USDA, but also felt keenly aware that his access to these resources was due to his institutional affiliation (Van Aken is an Associate Professor in the School of Art at Syracuse University). *Open Orchard* was conceived to make these rare varieties available again for everyone to pick, taste, and modify. He considered a title for the project based on the notion of orchards as commons in Medieval Europe. Then he learned about a philosophy in the Lenape culture "Where essentially, a tree couldn't be owned. You could only come to be gifted the fruit off of the tree." *Open Orchard,* with its echo of open-source culture where nothing is proprietary, and anyone can sample and rearrange, clicked into place.

"Culture evolves out of agriculture," Aken says, "and this idea of sharing is an essential component of that, whether that's seeds or knowledge or technology." The orchard on Governor's Island has been purposely planted with alternating rows—apples every other row, stone fruit in between—so that there can be a (free to the public) harvest within a few years, and so that the apples will be at their peak when the stone fruit trees age out of productivity.

But if no one "owns" the trees, who looks out for them? With global warming in mind, irrigation has been installed in *Open Orchard,* even though orchards don't typically have irrigation. Being on a hill puts the orchard above the flood plains, and the orchard is planted with drought-resistant fescue grass. Van Aken and the island's horticultural team have been working closely on the project since he began grafting the trees for it in their greenhouse 2018, and this close relationship is contractually obligated for at least five years.

Van Aken also sees his workshops and community garden tree placements through Green Thumb as part of the orchard's future-proofing process. "Experiencing the fruit is one way of understanding it—aesthetically. But then empowering people through teaching is another way." Van Aken also describes people becoming excited by reconnecting to their personal histories through caring for their local trees as a strategy for keeping fruit knowledge alive for another generation. Grafting, too, he sees as extremely motivating, almost a mystical experience—a fall graft blossoming in spring still thrills him even though he does about 3,000 grafts a year. "I can talk to people about grafting. I can show them how to graft. I can completely give away all the knowledge. But when that graft takes for that person and they have a thing that they grafted, all of a sudden the mysticism of it comes flooding in."

When meandering among *Open Orchard's* young trees, imagining them coming into maturity as the view and landscape around them alters due to planned development and unplanned impacts of climate change, it feels as though Van Aken is also grafting in some deeper way—binding forgotten knowledge and biodiversity in place now, to posit a surprising alternative future, branching off from the one we are barreling toward now.

Asian Long-horned Beetle Scouting

By Rachel Lawlor, Arboretum Gardener

1815

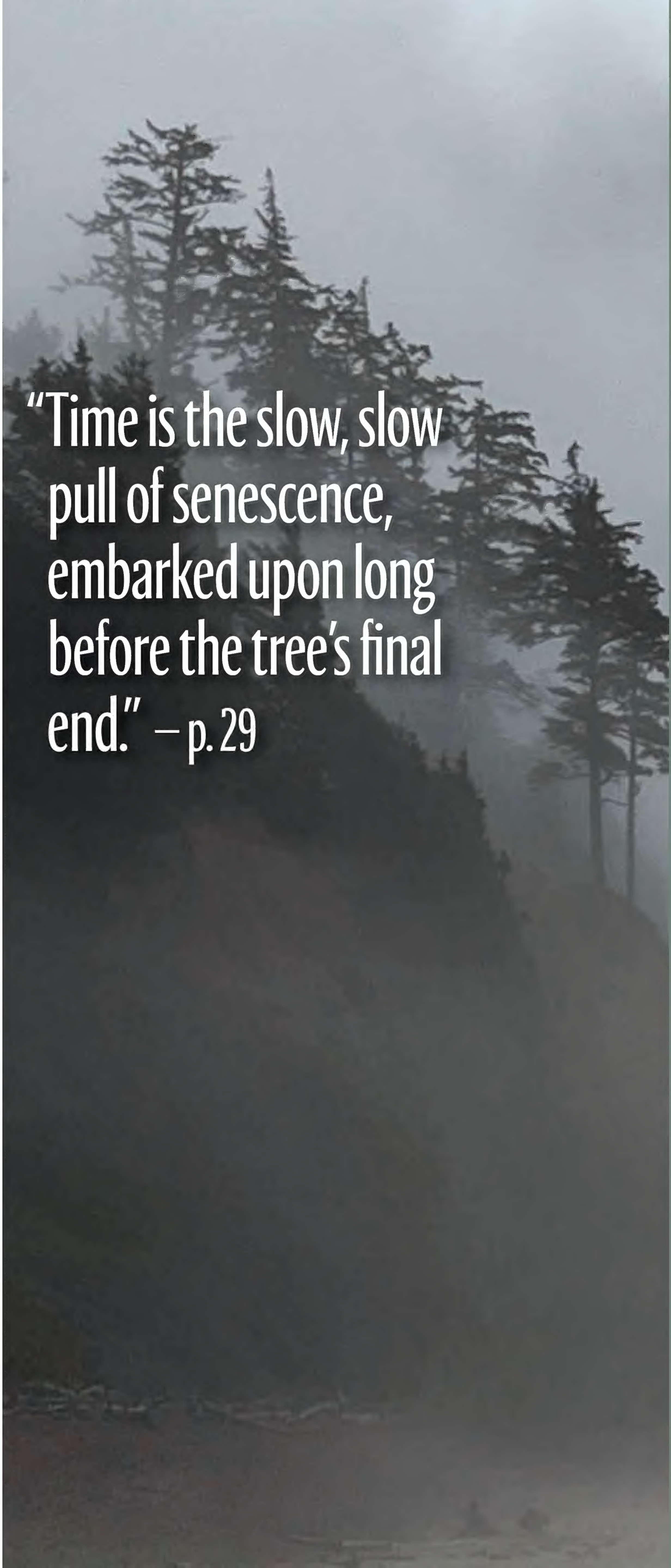
Accessions on the susceptible tree list.

60-90

Trees surveyed per winter.

Every winter, teams of horticulture staff members scout a random assortment of our susceptible trees for the presence of the invasive Asian long-horned beetle (*Anoplophora glabripennis*). Maples, elms, willows, horse chestnuts, and poplars are some of their preferred hosts. We record the DBH of the tree, note the start time, and scan the trunk and each branch of a selected tree with binoculars, which is much easier when the trees are lacking foliage. We're looking for any egg-laying sites chewed into the bark by the females, or exit holes from emerging adults after tunneling and feeding on the tree's sapwood and heartwood. A single tree, tall enough and with a spreading crown, could take a group of three over an hour to scout, or a cumulative three work hours to check that specimen. Luckily, ALB has not been detected in the Arboretum. For the health and safety of our collections, we will continue to be vigilant in our yearly scour of the landscape for this destructive pest.

Horticulture staff scanning for evidence of infestation. *Photograph by Rachel Brinkman*



"Time is the slow, slow pull of senescence, embarked upon long before the tree's final end." – p. 29

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